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CENTENNIAL EXHIBITION—U. S. DEPARTMENT.

THERE is a very interesting exhibit made by the Engineer Corps, which is represented here by Capt. D. P. Heap, of the Engineer Corps, assisted by Lieut. S. S. Leach, U. S. Engineer, and a detachment of a corporal and seven privates.

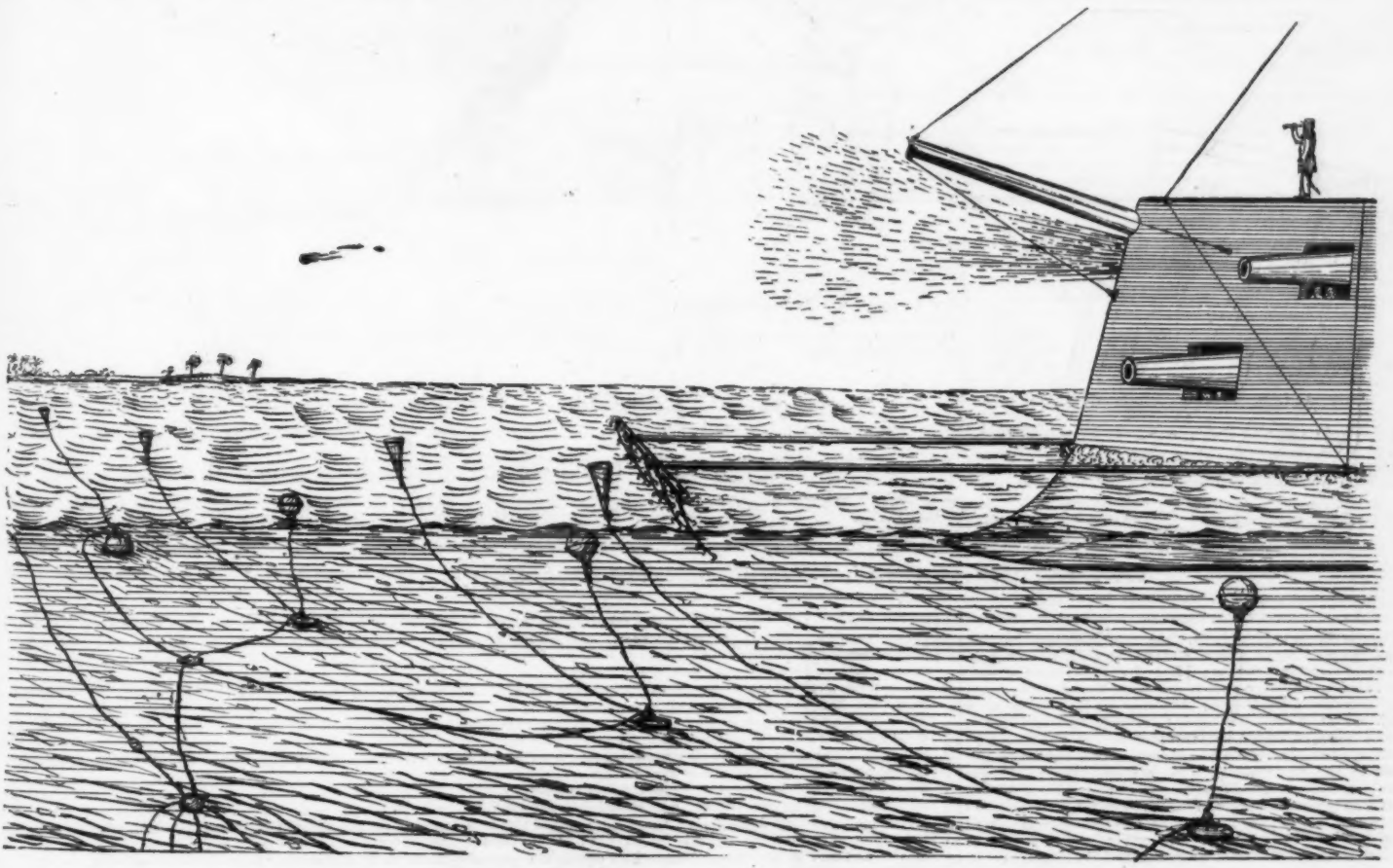
TORPEDOES.

There is a set of U. S. apparatus for operating and testing torpedoes, with samples, models, and photographs of the explosions and results; among the electric instruments are a galvanometer of Siemens, another of Bradley's, and a rheostat upon the Woodbridge principle. Of the torpedoes themselves there are shown two classes—the buoyant and the ground torpedo; the latter being for use in shallow water, the explosive material, or shell, is placed on the bottom, secured in position by an anchor weighing some 500 lbs. When set, this torpedo contains 200 lbs. of dynamite; a rope connects this with the buoy above against which the enemy's vessel is supposed to strike, exploding the torpedo. There is also a connection by wires to the operator on land, who can thus explode the torpedo at will.

The buoyant torpedo, as its name indicates, is made to float, and is held by cable and anchor as far below the surface as may be desired; this is the kind used in deep water. Attached to this by cable connection is a buoy which floats in such a position, as relates to the torpedo itself, that the enemy's vessel, if provided with an outrigger, shall strike the same against the buoy and explode the torpedo as the vessel itself comes over it; or, if unprovided with any outrigger, the bow of the vessel would strike the buoy while the torpedo was yet covered by the ship's bottom. This is also connected to the land batteries. These torpedoes are planted in grand groups of twenty-one, each grand group being composed of seven small groups, as shown in the accompanying cut, of three each. The cable of each torpedo leads to a triplet connection—literally an iron clamp protecting by two plates the junction of the cables from injury. The outer covering of each cable is unlaid, turned back, and formed into a kind of turk's-head, or knot; this is laid into a socket in a cast-iron plate, and securely held by a clamp; the ends of the three wires are then connected to the wire of another cable which is held in the same way, and the whole covered by another or guard plate. These connections are each insulated and left slack, so that any strain upon one of the cables is transmitted by the turk's-heads, clamps, and plate to the covering of the other cables without danger of injury to the wires. These cables are again, by similar clamps and connections, brought into one of seven wires which is led to the shore. In case of break in the covering, or when it is desired to connect two ends of a single cable, the covering is turned back as before, and a single clamp used. To locate the particular small group of torpedoes, belonging to each wire of the seven-parted cable, so that the operator can explode the ones he chooses in any case, the officer at one end of the cable attaches his battery to one of the cables, and starts the current; the electrician at the other end applies his wire to each of the seven ends presented at his hand in succession, until the current is found establishing the identity of that wire; the others are then located by counting to right or left. Among the experiments made by General Abbot, at Willett's Point, were some of particular interest in looking for the law of the transmission of forces. A model of the apparatus used and photographs of the explosions and results are shown. The machine used consisted of a crib, or frame, made of flat metal bars, every bar used being set edgewise, or in a plane radial to a central point, to reduce the effect of the explosion upon the frame itself to a minimum; this crib was about 80 feet long by 20 feet high and 20 feet wide. To each of the joints or intersections of the bars composing the crib is secured a pressure-gauge in the proper position; these gauges are analogous to those described as being used in the Ordnance Department. The torpedo was suspended in the centre of the crib, and at each experiment careful note was taken of each of the following points—the size of charge and description of the torpedo, the temperature of the water, the whole depth of water at the place, and the depth of submergence, or the level at which the crib was located. From these data, established by a series of experiments, General Abbot deduced and formulated the laws of the transmission of forces through water.

HELL GATE.

The operations under General Newton for the removal of the obstructions at Hell Gate are here illustrated by model and description, the model being made in two parts so that the roof of the excavations being lifted off the whole operation can be understood at a glance. The reef which this work was undertaken to remove extends into the channel about 800 feet, with a depth at low water, and at the distance of 270 feet from the shore, of less than 12 feet; around this point all vessels running through the Sound are obliged to turn, the angle being particularly short and dangerous for the large passenger steamboats of the various Eastern lines. In 1869 work was commenced by building a coffer-dam for the protection of the shaft, on a part of the reef near the shore; then a shaft was sunk to the proper depth, and the real work of the excavation commenced. This was to "drive" tunnels (ten in number), radiating from the shaft, under the river, until the depth from low-water level to the bottom of the tunnels of 26 feet was reached. These tunnels are about 14 feet wide, varying in height above their uniform bottom surface from 10 to 22 feet, leaving about 10 feet of rock everywhere for a roof; these are connected by cross-tunnels of the same width and height, and about 30 feet apart; thus large piers were left to be again subdivided, until finally there remained 173 piers, each about 10 feet in thickness. The area thus undermined is about three acres. The piers and the surface of the roof have also been drilled with numerous holes for the insertion of the cartridges for the final blasting, after which the labor will be reduced to simply grappling and removing the broken rock and débris. Similar operations have been commenced upon Flood Rock, another of the obstructions of Hell Gate. Another of the methods employed at Hell Gate, on Way's Reef, was the steam-drilling scow, a model of which is also shown here. This is a large and very strongly built scow, with a large well-hole in the centre; in this well is suspended a hemispherical frame or dome, covered with boiler iron, and having a diameter of 30 feet; this is sunk upon the reef, and operates as the foundation or frame-work for the drill-rods, the drills are raised and dropped by means of rope or flexible connection to the engines upon the scow; when the holes have been drilled to a sufficient depth, the dome is hoisted into the well, and the scow towed away; the charges of nitroglycerine are then placed in the holes by the diver, and the connection made with the batteries. The size of the drill-holes is about 5½ inches in diameter at the top, and the distance apart from 6 to 8 feet, the charges varying from 50 to 60 lbs.



THE INTERNATIONAL EXHIBITION OF 1876.—TORPEDO WARFARE.

RIVER IMPROVEMENT.

Analogous to the foregoing in its object and result, but with different material to operate upon, is the dredging illustrated here by the model of one end of a dredge-boat, originally designed by the late General McAlester, of the Corps of Engineers. As designed by him the boat was a strongly built, double-ended craft, carrying at each end a screw similar to a propeller. Upon driving this boat into the soft mud of a Mississippi bar, the screw in that end being set in motion, and the mud thereby stirred up and loosened for the current to remove, the boat would be withdrawn and again drove into the bank to repeat the operation. This has been improved by Capt. Howell, of the Engineer Corps, by the addition of a deflector, and other mechanical details. The deflector is an iron hoe or scraper, which extends across the whole breadth of the vessel's stern, and which is dropped into the mud, after it is loosened by the screw, to drag it into deep water at once. There is also a model of what may be called a "partial dry-dock," being a caisson or dock, arranged to take the stern of a vessel, and, after making a packed joint around under her run, it is pumped out, allowing men to work freely upon the propeller and parts of the hulk adjacent. The dock is provided with chambers, which are filled with water ballast to counteract the tendency of the dock, when pumped out, to float up with and strain the vessel. There is also a box, or shaft alley,

extending out from the dock, permitting the propeller shaft to be taken entirely out, as was done with one of these dredge-boats, without removing her from her location at the isar.

Auxiliary to the improvement of the rivers is the sounding machine used in the improvement of the Rock Island and Des Moines Rapids of the Mississippi River. This machine, of which a model is on exhibition, was designed and constructed by Major E. F. Hoffmann, Assistant Engineer, under the supervision of Col. J. N. Macomb, Corps of Engineers, U.S.A. It is a combination of ten individual sounding-rods, and takes ten soundings at each dip. The rods are placed in pairs upon five small flat-boats, arranged abreast, and secured in place by a frame-work, giving a total breadth of one hundred feet. The centre flat-boat is something larger than the others, and the whole are secured across the bow of a steamer of very light draught, in such a manner, by guy-rods or braces, that she can move the whole with certainty and despatch. The sounding-poles slide in boxes, and to prevent the current from springing them out of plumb a guy-line is attached to the foot of each, carried up stream to a leading pulley attached to the frame, and back to a shaft, which unwinds and slacks the line just as fast as is requisite to permit the descent of the poles, and no more. On striking the bottom, each pole trips the pawl of its counterpoise weight, which draws the pole up again. In the top of the box of each sounding-rod is a wheel, which the descending rod causes to revolve. This, by winding up a cord upon its axle, draws a small rod that sets in motion a sharp-edged wheel, that, pressing upon a sheet of paper, makes a mark, agreeing in length with the depth of the sounding upon the prepared scale.

The frame is located, for each sounding, accurately by theodolite observations, and the superiority of this method over the old hand-work plan, in cases requiring great accuracy of detail, is obvious. Its advantage in regard to expense is stated as rather more than three to one.

BREAKWATERS ON THE LAKES.

There are two models of wooden cribs for breakwaters, showing all of the details of construction—the one for Oswego by Major John M. Wilson, and the one at Dunkirk by Lieutenant-Colonel C. E. Blunt, Corps of Engineers, for Major F. Harwood, Corps of Engineers.

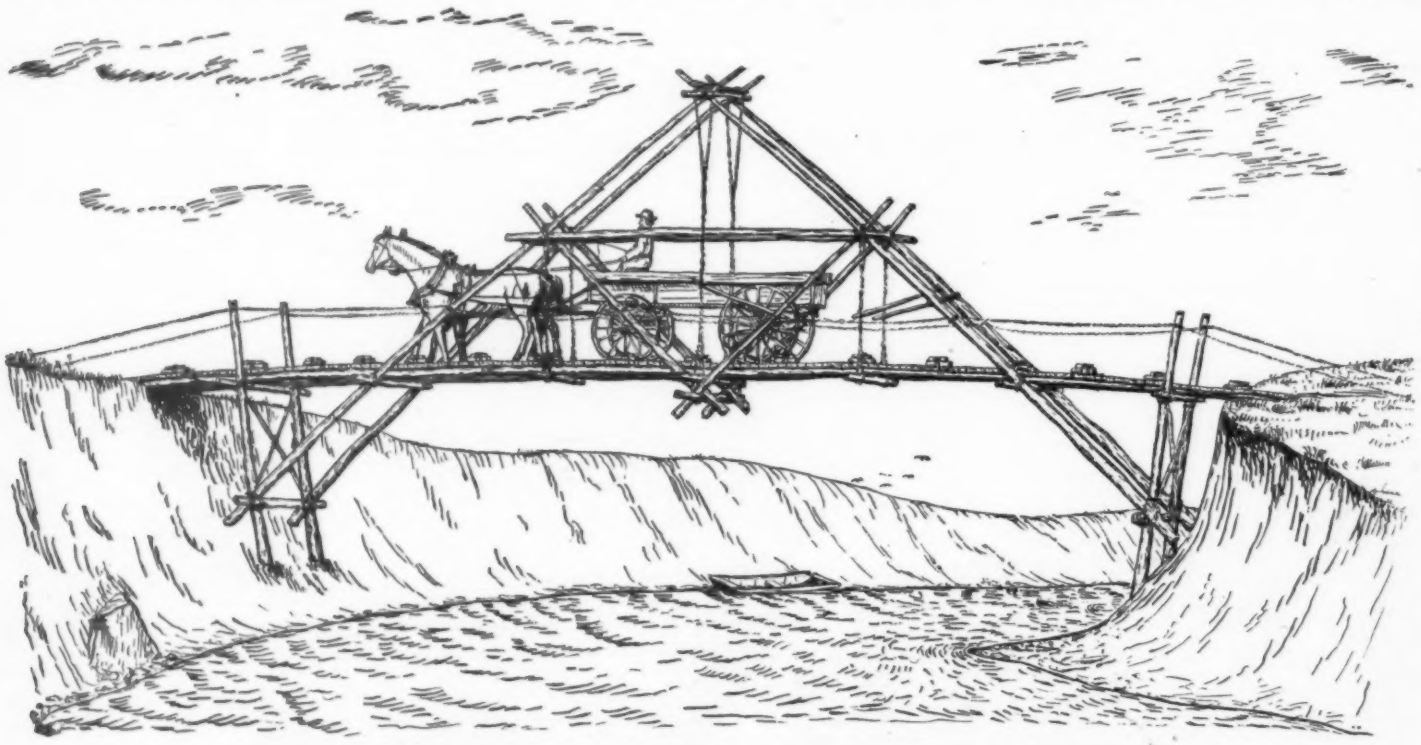
BRIDGES.

There are shown models of pontoon bridges, and complete pontoon train, with wagons, and all of the material carried for that work. There is also a model of a bridge bearing the name of Sergeant N. Gentner, Co. A, Battalion of Engineers. It is worthy of note, not merely as a piece of military engineering, but also as a very easily constructed bridge for the farmer, and also as a picturesque design for the landscape gardener. A sketch of it is given herewith, from which the whole plan of construction can be seen at a glance. Note that in such structure all nails or spikes should be avoided, the slight motion of the parts rendering them, if any thing, worse than useless. Learn rather to knot a rope, and lash with a cross-seizing. The suspension ropes are twisted to the proper tension, and toggled after the manner of the old-fashioned buck-saw. With proper care, and kept in order, this is one of the cheapest and safest bridges a farmer can use.

THE SIGNAL SERVICE DEPARTMENT.

The Signal Service Corps, represented here by Lieutenant Grugan and his soldierly assistants, seems to be in close communion with our promising friend, "Old Probabilities," with printing-press, and the necessary type, correcting, or rather completing, meteorological charts for the day, and exhibiting a number of very fine and ingenious instruments peculiar to their class of work, consisting of anemograph, or self-registering machines, showing the force of the wind. Of these there are several, by A. C. Rugge, Lieutenant D. J. Gibbon, and Private A. Eccard. They all agree in their general characters; the pressure of the wind being found by the speed with which it revolves a small windmill, made of four hollow hemispherical cups set at the ends of four horizontal arms, upon a vertical shaft, the number of revolutions per second giving the force of the wind, the area of the cups, and the power required to turn them being known. The registering is done by an electric chronograph arrangement similar to that described in a former article upon the transit of Venus. There is also a barograph, by Private H. L. Foreman; this is also self-registering. The barometer tube, shaped like the letter J, being close at the top, is filled with mercury from the bottom, and then being reversed, the column of mercury descends in the long part of the tube, leaving a vacuum above, until the weight of the difference of the mercury in the two columns just equals the pressure of the atmosphere upon the area of the tube. The short end of the tube is left open, and a ball floating upon the mercury is attached by a fine wire to the electric chronograph, giving by its rising and falling the exact pressure of the atmosphere at any given time. Similar instruments, but differing in detail, are shown of the designs of Lieutenant D. J. Gibbon and Private A. Eccard, and a marine barograph, the whole of which is suspended to swing freely, and without injury, by the motion of a vessel. The thermograph, by G. W. Hough, has a thermometer with a tube open at the top, and a ball floating upon the mercury registers, in a manner similar to the barograph described, the fluctuations of the mercury due to its expansion and contraction with the variations of temperature.

A. V.



THE INTERNATIONAL EXHIBITION OF 1876.—MILITARY BRIDGES.

NEW INLET, CAPE FEAR RIVER.

The operation at New Inlet, Cape Fear River, having for its object the opening of a new channel in a direction and location more accessible to inward-bound vessels than the present one, is being carried on in a manner different from either of those described, the idea in this case being to make an artificial bar at New Inlet, and thus turn the water into the desired path, causing, by the increase of the current, the scouring of the bottom, and consequently a greater depth of water in the right place. This artificial bar, as shown by model, consists of a raft of rough timber bolted together; upon this is placed a layer of brush or cedar boughs, and the whole sunk by loading with stone, the theory being that the brush will, by breaking the strength of the currents, cause the deposition of the sand or sediment held in suspension by the motion of the water, whether ocean wave or river current, and the whole will be permanently buried by a new bar without farther expense; or, if desired, another and narrower raft may be sunk upon this bar, hastening the work, and bringing it still nearer the surface. The work, which is illustrated by charts of the locality, as well as models, is in charge of Major Wm. P. Craighill, Corps of Engineers, and has been under the personal supervision of Captain C. B. Phillips, Corps of Engineers.

GALVESTON HARBOR IMPROVEMENT.

This work resembles that at New Inlet, inasmuch as that it also proposes to plant a seed that shall grow by the action of the waves themselves into a bar or breakwater; but the work is performed in a totally different manner. The principal material used here is the wild cane abounding in the vicinity. It is first made up into gabions, having a wooden bottom and top. These gabions are ten or twelve feet long by six feet high and six feet wide; they are plastered with concrete or hydraulic cement, and the bottoms made tight and ballasted with the same. When towed into position, they are sunk in line, close together, then pumped full of sand. Fascines, of the same canes, are posed against the interstices, at the ends, and weighted in place with concrete. A layer of canes is also laid on each side, as an apron, to prevent any danger of under-cutting by the wash, and also weighted with concrete; as the sand fills in on the back of the gabions, another tier can be placed partly on the first, partly on the sand, and thus the work raised as high as may be needed. The expense of this work is said to be only $5 per running foot.

In this model, the road crossing the stream diagonally, the two sets of cranes swing in contrary directions for convenience: this is by no means essential. There are here four pairs of cranes carrying a double-track railway; all of the cranes on one side are tied, and gauged by hinged tie rods or connections, and a diagonal brace, secured by a clamp when the bridge is closed, holds them in position; and, being tied together, when the clamp is released, one pinion and segment operates the whole at once. The cranes are made of iron, and swing from stone abutments. It will be easily understood that the weight of the cranes may be reduced to a minimum, forming as they do a complete arch when closed, and therefore the pintles on which they swing may be small, while, as they may close into sockets in the masonry, there need be no strain whatever from the passing train upon the pintles. The plan is worthy of consideration, in that it unites strength, economy, and ease of operating, to a degree seldom attained in drawbridges.

The same Department of Public Works also exhibits models and drawings of the dykes and embankments that literally make that country what it is; of the fidelity and accuracy of these representations we can have no doubt, when we see real mussel shells, of proportionate size, in the interstices of the stone-work. A careful study here gives some idea of the work to be performed at the mouth of the Mississippi and around New York City itself.

In the Department of Mexico is seen an agrometro, an instrument that, as the label on it tells, will measure, within a centimetre, a distance of forty-five hundred metres, or, in English, within a half an inch a distance of nearly a mile. It is simply a perambulator wheel and index gear with a single handle; a kind of instrument not unknown to surveyors, but presented here in a very convenient form, and from an unexpected direction. It being a noticeable feature of this exhibition that the great nations of England and France treat it as only a show shop for jewelry, pottery, or other merchandise, while the smaller and less wealthy nations put their best foot foremost, as the old saying is, in a progressive and scientific light,—thus Sweden displays, in the Swedish school house, a Thlorell's printing meteorograph, built by Sörensen. It is really an ingenious combination of printing wheels, paper, and an electric motor; it prints six columns upon the paper, each column having its own type wheel controlled by, first, an anemometer, giving the force and direction of the wind; second, a barometer giving the atmospheric pressure; third, a chronometer, giving the time of the observations; fourth, a hygrometer, giving by August's method the amount of moisture in the air; and fifth, a thermometer, giving the temperature. The observations are self-registered every quarter of an hour; the clock requires no winding up, the tension of the main spring being restored every fifteen minutes by the electric force, hence it will run as long as the electric current is unbroken. The supply of paper is sufficient to last three months, so that it may be left to itself, in situations like the top of Mount Washington, performing the labor of a corp of twelve observers, and giving the results in very convenient form. The portions liable to injury by frost, or to oxidize, are protected by a zinc case made perfectly air-tight, and containing chloride of lime and caustic potash. An instrument of this kind has been in continuous operation at Upsala for two years, without showing any material deterioration, and the Swede offers to make upon this principle an instrument to register observations of any other phenomena, provided "they can be indicated by an index which produces a galvanic contact." In the American Department of the Main Building is an exhibit of certain machines by William A. Rogers, Cambridge Observatory, Cambridge, Mass. They are labelled only as machines for grinding and polishing diamonds for engraving glass, and ruling and dividing machines for making microscopic lines on glass; one it is said will rule 80,000 parallel lines in one inch. But for want of some easily read description, or better, some person versed in the subject, crowds pass by, none the wiser. One will ask, "What are these machines for?" and a blank silence falls upon the crowd; some one reads the label, and the word 80,000 lines in one inch is passed around, till one, perhaps a student, asks "How?" and "Why?" and in blanker silence than before the crowd make room for others: this is the very burlesque of exhibition. That which is needed is not merely to, as it were, whisper that the machine can do this, but to show some definite connection between that work and some point of known value among the needs and luxuries of the day. Let it only

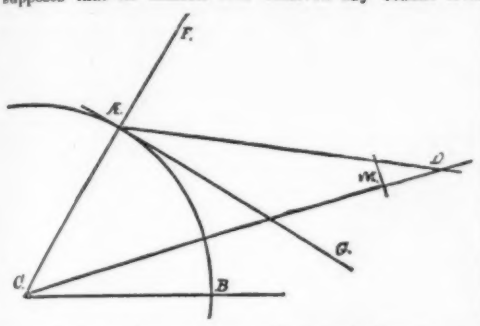
CENTENNIAL EXHIBITION.

In the Netherlands Department of the Main Building is shown the model (accompanied by drawing in detail) of a double crane, or swinging bridge. It is exhibited by the Department of Public Works, and is built over the canal 'Delfsharensche schie," on the Amsterdam and Rotterdam Railway. This plan of bridge, for railroad purposes, has real merit: it consists of a series of cranes, similar in form to those that supported tea-kettles and dinner-pots in the fire-place of the old time; each crane carries on top one rail of the track, and reaches half way across the stream, there meeting the crane from the opposite side, like a double farm gate; the simile is complete when the squirrel runs across the gate, like the locomotive over the cranes.

be said that half a century ago mother-of-pearl was imitated by such lines on metal, and it was proposed to make buttons in this way; or that by means of scales, graduated in such a manner, can be measured the feathers of a butterfly's wing, and the machine shall rise to the value of a button machine at least. Let it be shown that such work is an assistance in counting the number of vibrations required to give the musical notes of the prima donna, and the more full the description the more is the work appreciated, and the people learn something. A. V.

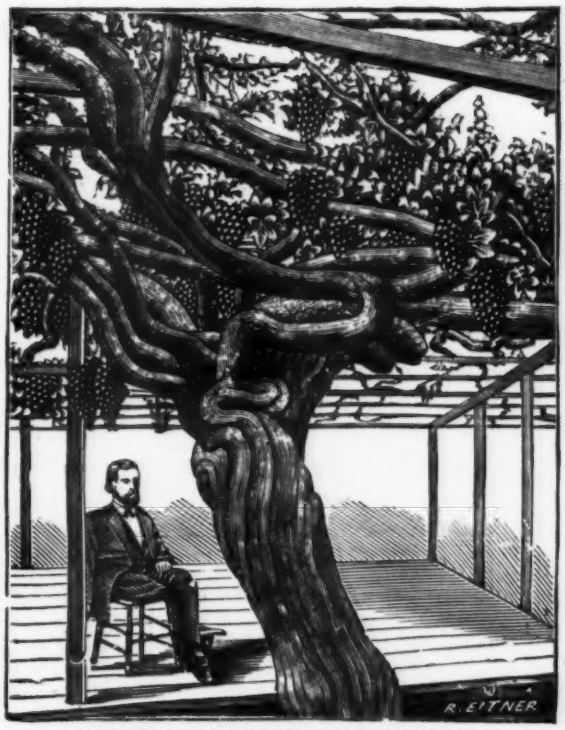
CENTENNIAL EXHIBITION.—UNITED STATES DEPARTMENT.

NEAR the northwest corner of the United States building stand three small plain wooden buildings, as little likely to attract attention from a stranger as any upon the ground, yet containing instruments for one of the finest operations of astronomical science, being the apparatus used in observing a transit of Venus. Astronomers simply say that the object of the observation was to obtain, correct, or verify the sun's parallax. But to find out what is the sun's parallax, and of what use to scientific men? For no ordinary man supposes that he himself ever received any benefit from



it. Referring to the accompanying diagram, let C represent the centre of the earth; the curve A B a portion of its surface, the line C B showing the equator. Suppose a man at A desires to know what latitude he is in—that is to say, the angle A B C. The range of his vision is limited by the horizon, and he can see or note nothing below the level shown by the straight line A G. Now, knowing the time of the year, he may ascertain from previous calculations that the sun is actually in the position marked D; in astronomical parlance, he knows its right ascension and declination—in plain English, he knows the angle D C B; and as he can see nothing of C or B, he, working with what he can get at, tries to find the angle A C D, or, as he says, the sun's correct zenith distance, knowing that if he can obtain that, he can add thereto (or subtract therefrom if the line C D had happened, as it sometimes does, to fall to the other side of the line C B) the angle B C D already known, and obtain the desired angle A C B. With the sextant he observes the angle D A G; subtracting that from ninety degrees, he obtains the angle F A D; but the angle F A D is larger than the angle A C D (or what is the same thing, F C D), and it is just this difference that is called the sun's parallax; and this difference will not only vary in degree, as the observed angle D A G is larger or smaller (being absolutely nothing when D A G is equal to F A G), but also it will vary with the actual distance, or length of the line C D. And when you saw the captain take an observation of the sun in coming from Europe, you were not likely to imagine the amount of calculation and correction gone through by him, or some scientific man who prepared the tables, to which he trusted, that gave that observation its whole value in showing where you were at that time. (The corrections for dip and refraction are purposely omitted for the sake of simplifying the subject, and because they do not affect the truth of the points stated.) From the above it will be seen that any one wishing to find the exact distance of any place from the equator or the angle A C B, must not only know the exact position of the sun in his apparent path in the heavens at that time, as already calculated and shown in his nautical almanac; but also the true parallax or correction to be applied to his observations, to reduce the apparent angle F A D to the true angle F C D.

But to get this parallax correctly, it is necessary to know the exact distance of the sun from the earth, or length of the line C D; and paradoxical as it may seem, that distance is determined by this same parallax. Suppose in the diagram the line A B as before represents a portion of the earth's circumference; C, the earth's centre; C B, the plane of the equator; D, the true position of the sun; M, a planet passing directly between the earth and sun. Now, as the sun D is really so much larger than the earth, and as the distance C D or C M is really enormous, the planet M will appear both between C and D and between A and D, for which reason in the diagram it is indicated by the line M, cutting both the lines A D and C D. Now the observer, taking as before the angle D A G, by several observations taken at once proves its correctness. Then the value of his work depending upon the certainty with which he can determine the angle D C B, he has previous calculations showing with absolute certainty that the sun will apparently travel through a particular part of the heavens, and at fixed times is in certain places; but it is always changing its place both with regard to east and west, and also with regard to north and south, so that it is necessary to know the exact time to as fine a fraction as possible. But all mechanical means of determining time are corrected and regulated by the observed motions of the very bodies it is now necessary to locate and verify; hence the time must be determined by the heavenly bodies themselves, as the only real and unchangeable standard. Again, by referring to the labors of scientific men for ages past, it is found that certain of the planets will pass between the earth and sun at periods that have been calculated with great precision, and proven by experience covering many actual passages, or, as the astronomer, in deference to his Latin teacher, calls them, "transits." Knowing then that at a certain time the sun would be at a place, say D of the diagram, and that at the same instant the planet M will be on the line C D, he inverts the proposition, and says, "If I can take the angle D A G at the instant that M is on the line C D, I have proof that the sun is in a certain part of his apparent path at the time I take the angle, and therefore I can find the angle D C B with accuracy and certainty." Next he adds the apparent angle D A G to 90°, obtaining the real angle C A D, and subtracting the angle D C B from the angle A C B (found and proven by many observations of both sun and stars, still more remote and open to less error), and obtains the angle A C D, whereby he constructs the triangle A C D; and knowing the length of the side A C, or one half the earth's diameter, and the value of the angles at A and C, he easily deduces the length of the side C D, or distance of the sun from the earth's centre, and thereby works up his tables of correction for parallax, for the use of all future time, doing thereby a good turn not only to every man who goes to sea, but who ever uses an article brought, like tea or coffee, or even a Norway iron horse-nail, from abroad. But to return to the instruments upon exhibition, and which were used by the party under Prof. Harkness (who, we are informed, designed them himself) in observing the transit of Venus a year or two ago; and right here let it be noted, that any person desiring to personally inspect these instruments or any other part of the exhibit of the Navy Department, need only apply at the headquarters in the United States building, in charge of Rear-Admiral T. A. Jenkins, assisted by the Professor and the affable Lieut. Davenport, and their wishes will be most fully and agreeably attended to. Is it necessary to add that there is no charge for information in such cases? First the visitor is shown a small pine-board structure, containing only one room, and with the roof arranged so that by opening a narrow shutter part of the heavens can be seen, while the excess of light from the rest is in a measure cut off. In the centre of this building is a fine transit instrument, which consists of a telescope hung upon trunnions so that it can be swung in a vertical plane, which plane is very carefully adjusted by levelling and observations of the stars, so that it may coincide at the same time with the line of motion of the centre of the telescope, the centre of the earth, and the north and south poles—or, in astronomical language, "on the true meridian." The trunnions of the instrument are hollow, and a lamp is hung at the end of one of them for use in night observations; in the centre of both telescope and trunnions are certain fine wires that indicate the exact centre, and certain known distances on either side of it; and the only use of the lamp is to render these wires visible to the observer. With the wires is a mirror so arranged that the observer sees the image of the star observed appear to pass across the wires as it passes the meridian; and here this instrument differs from the common form in use among surveyors, etc., in the fact that the eye-piece of the telescope is placed at the end of the other trunnion, and opposite to the lamp. The advantage of this as a matter of convenience will be apparent to every observer, since in this case the position of the eye and head remains unchanged, whatever the altitude of the object observed. These trunnions rest in solid pillar blocks, carefully levelled, and are provided with a pivot carriage, which, by means of a hand-lever and cam, will lift the telescope and trunnion free from the pillar blocks, when it is swung around and replaced in the pillar block, but with the trunnions reversed and the observation repeated. If the observation of any fixed object (the farther off the better) gives the same result with the trunnions in both positions, it proves that the axis of the telescope and centre line of the trunnions are correctly adjusted to an angle of ninety degrees, and the future observations are to be trusted in that respect. This instrument has also the usual graduated circles, with verniers, etc., to measure angles of elevation or direction; also levels and collimetres for adjusting and perfecting the arrangements. It bears the maker's imprint of Stackpole, of New-York. There is also in this room a "Break Circuit Chronometer"—that is, a chronometer that being itself very carefully regulated will, at regular intervals, momentarily break an electric current, connecting with some other instrument; in this case a chronograph or cylinder carrying a sheet of paper under a fountain pen, which traces a line of ink like a screw-thread upon the paper. This pen is hung by a spring in front of an electro-magnet; the breaking of the current by the chronometer causes the magnet to suddenly draw the pen to one side, making a notch in the line on the paper; and whatever the actual speed of the paper cylinder, or distance between the notches, that distance represents the space of *time* between the breaks made by the chronometer. Other keys are furnished the observer which break the current by merely pressing with his finger, causing the pen to make marks similar to those made by the chronometer, but so spaced in relation to them as the finger break was timed in relation to that of the instrument. Outside of this building, and at a little distance, is a firm pedestal, upon which is fixed a heliostat, or arrangement for receiving the image of the sun or body observed, and reflecting it directly into the camera of the photograph building. A metallic rod or tube is used to measure exactly the distance from the heliostat to the camera, for adjusting the focus. The photograph building differs from an ordinary photographer's dark room, only in being provided with key-board and telegraphic communication with the transit house described, and a black-lined tube pointing to the heliostat, and being located so as to bring the centres of the camera, darkened tube, and heliostat very accurately into line with the meridian of the transit instrument itself. There is also a sliding panel with a narrow slit through it, which covers the opening of the blackened tube, and being slid quickly from one side to the other permits a momentary flash from the heliostat to pass through the slit into the camera, and at the same time passing over a projection, on a spring connected with the chronograph, again breaks the circuit, showing, as in the other cases, the precise fraction of a second at which the photograph was taken. Thus the negative plate being placed in position, and word telegraphed to the transit observer, "all ready," the observer noting the instant that Venus appears in contact with the sun's first limb or edge, presses his key, noting the time on the chronograph, and telegraphing the photographer to "go;" the photographer simply shoves the slide across, thereby admitting the required light to the negative plate, and also registering the time upon the chronograph; the negative being numbered and immediately replaced by another plate, the operation can be repeated, giving as many photographs of different stages of the transit as may be desired, with the times of taking each, and the times of transit over the wires, etc., registered upon the same sheet of paper, to be read and compared at leisure. A little to one side from the photograph house is another small building with a roof arranged to turn or open at pleasure, and containing an equatorial, or telescope, so hung upon a pedestal and governed by clockwork that it can be made to turn slowly, keeping any particular star or the sun in view for a long period of time, without effort on the part of the observer, who is thus at leisure to watch the coming on and going off of the transit, and make his notes and observations. It bears the maker's imprint of A. Clark, Cambridgeport, Mass. The result of the late expedition is roughly stated as being the correction of previous errors, showing that the distance from the earth to the sun, instead of being ninety-five millions of miles, as the school-teachers used to tell us, is really between ninety-one and ninety-two millions only, and thus giving data for a revision and correction of the tables of parallax in daily use by the navigator. A. V.



MAMMOTH GRAPE-VINE IN AGRICULTURAL HALL.

THE MAMMOTH GRAPE-VINE IN AGRICULTURAL HALL.

BOTH ancient and modern history give instances of very large grape-vines, none of which, however, equal this mammoth vine of Santa Barbara, California. The great doors of the Cathedral of Ravenna are made of vine planks, some of which are said to be twelve feet long and fifteen inches broad. The columns of Juno's temple, Metapont, and also a statue of Jupiter for the city of Apolonium, were made of the wood of the vine. The Queen's vine at Hampton Court, England, the largest and most noted of the Old World, only equals in diameter one of the main branches of this vine. Rev. Robert Bently, in his thanksgiving sermon delivered at Santa Barbara, November 30, 1871, thus refers to this vine: "A nuncio from Rome, who visited this place not long since, and who, in his observations and readings, had made the vine the subject of his specialty, asserted that the great grape vine of Montecito is as large again as the famous vine of Fontainebleau, France; larger than any found among the villas in the vicinity of Rome, and surpasses any of which Pliny gives record in his history and travels." The history of this celebrated vine is both curious and interesting. The various theories respecting its origin and early history are based on traditions handed down through several generations, and though founded on the real, all have an air of romance.

At a meeting held at Santa Barbara, California, the following preamble and resolutions were adopted: This famous vine is without doubt the largest in the world. The celebrated vine at Hampton Court, England, grown under glass, is nine inches in diameter three feet from the ground, and nearer to the ground has a measurement of eighteen inches in diameter, or fifty-six inches in circumference, while its foliage has long covered a space equal to 10,000 square feet. The Hampton Court vine produces annually from 1500 to 2000 pounds of grapes. The product of this vine, as estimated by Dr. Ord, one of the State Commissioners to the Centennial, Judge Huse, and others, has often reached the immense number of 7,500 clusters, of an average weight of 1¼ lb. each, or nearly 12,000 lbs. It is of the variety known as the Mission Grape, and was planted by Dona Maria Marcelina de Dominguez, at the birth of a child, according to the custom of the country. Its age is between 50 and 60 years. For several years it has shown evident signs of decaying vigor, and has now been dug up, sectionized, and boxed (after weeks of labor), for removal to the East. In view of this removal, be it

Resolved, That we take a deep interest in the fate of this vine, which has been so long recognized as one of the chief curiosities of Santa Barbara, and we heartily approve of Mr. Sarver's plan for exhibiting it at the Centennial, where it will stand as an indisputable proof of the rare adaptation of our soil and climate to the culture of the grape, and where its enormous proportions and unequalled fruitage will form no unfit symbol of the extent and resources which the country has attained during the century just closed.

Resolved, That we feel the less regret at its removal from the fact that there remains upon nearly the same spot a daughter vine, which also outranks the Hampton Court vine, being now sixteen years old, and sixteen inches in diameter three feet from the ground, and making growth at the rate of an inch in diameter annually, having the last year furnished from 8,000 to 10,000 pounds of grapes, which were plucked and eaten by visitors from August 15th to January 20th.

Resolved, That we heartily commend Mr. Sarver as a citizen whose worth and integrity are recognized by our entire community, and whose enterprise and enthusiasm in this undertaking are deserving of an ample reward.

J. W. HOUGH, Pastor Cong. Church,
J. A. JOHNSON, Editor *Press*,
C. E. HUSE,
Committee on Resolutions.

CHARACTER OF THE FRUIT.

The fruit is the size of ordinary grapes, of pinkish purple color when ripe, and of good quality, the bunches weighing

from one to five pounds each. It is an excellent grape for table use and for wine.

HAS STOOD THE TEST FOR A CENTURY.

It is a very hardy variety, and has stood the test for a century. It is about the only kind retained by the Spanish residents, whose forefathers introduced it with other varieties from Spain upon the first settlement of this country. Having been introduced by the Spanish missionaries, and being the chief variety retained and cultivated by them at their missions, it became known as the Mission Grape.

NATURE OF THE SOIL.

The soil in which the vine grew is a dark sandy loam, with a very solid subsoil of clay, where the vine stood, about eighteen inches below the surface of the soil. The vine had four large roots (each of which was six inches in diameter near the trunk), all running close together in a north-eastern direction, the trunk leaning in the opposite direction. These roots were imbedded to the depth of an inch in this clay subsoil, which was too solid to be penetrated by them. At our request Rev. Stephen Bowers and Dr. L. N. Dimmick made an analysis of the soil, and reported as follows:

SANTA BARBARA, CAL., Sept. 20th, 1875.

Mr. SARVER:

Below is our analysis of the soil in which the big grape-vine grew: "An argillaceous and silicious marl, derived from the disintegration of the tertiary rocks composing the Santa Ynez Mountains."

L. N. DIMMICK, M.D.
STEPHEN BOWERS.

The soil is rocky, the rocks being mostly of a very coarse sand, which is easily pulverized.

HOW THE VINE WAS TRAINED.

The vine was developed in the beginning by securing it to a post to the height of about eight feet. All the small branches were cut off to that height, and all above that to the number of twenty were left on, and trained in all directions from the trunk, on a rude trellis. How closely it was pruned in those early days is not easily determined now from the appearance of the limbs. There are twenty main branches, the largest of which is twenty-eight inches in circumference. These, during the first five years, were but little cut off in pruning, in order that as large an area as possible might be covered in a short time. These main branches produced great numbers of young canes annually, which became large branches in the course of years. At this stage of development all the branches bear evidence of close and judicious pruning. Many of the minor branches show that their whole length of forty or fifty feet was attained by a length of one or two eyes being retained each year in pruning, which is the proper method, and the one pursued by us in pruning the young vines during the time they have been in our possession, the last three years; and thus were developed these beautiful vines. The proper time to prune these vines is from December till February. The treatment of the vine by its Spanish owners, so far as pruning was concerned, was proper, but the soil was entirely neglected and trampled upon by crowds of people till the earth underneath and around it became as solid as a road. The soil was left in this condition, and the process of trampling continued for years. It was never cultivated nor loosened in any way, so far as we could learn, except that it was irrigated once, or perhaps twice, a month during the dry season of the year. The water used in irrigating it was generally, but not exclusively, from the hot sulphur springs, which are located in a cañon of the mountains more than a mile distant. This water is conveyed by a ditch from the hot springs, but becomes cold before it reaches the vines. It is impregnated with mineral substances, and is very soft. It is supposed that the hot spring water possesses properties that are very favorable to the rapid growth of these vines. No other fertilizer was ever applied to the soil during the prodigious development of the parent vine.

DECLINE OF THE VINE.

Some five years since, the vine first began to show signs of decay. Numbers of the smaller branches began to die from time to time, and each succeeding year it continued declining in vigor, as was indicated by the shorter and more delicate growths of each season. At that period the vine required the vigorous cultivation of the soil, and the judicious application of fertilizers, neither of which it received. With proper management it might then, possibly, have been saved, and it might have continued to bear its wonted tons of fruit annually, and to flourish for centuries more. There is no question that its ruin was caused by the bad treatment it received from its Spanish owners during the last ten, but more particularly the last three years. It is very probable that it did not live out half its days. Three years since these Spaniards enclosed the vine with a tight board fence, and soon after that put a large dancing-floor under one side of it, reaching almost to the trunk of the vine. The trunk was then enclosed with a lattice-work, and the whole surrounded by a canvas on the sides, another being placed overhead against the branches, thereby almost totally preventing the access of sun and air to the body and roots, which hastened its decay. As the smaller branches were found dead they were cut off, so that the foliage was continually diminished. But during all these years of decline, those branches which retained even a small part of their vigor were annually laden with grapes. At the time of taking it up, the greater part of the limbs were entirely dry. All of the large roots were dead, and in such decayed condition as to crumble into dust eight feet from the trunk of the vine. All the remaining limbs were dried out and cracked open on the upper side, and only a small part of the under side of the limbs retained signs of life, yet strange as it may appear, these limbs were laden with grapes at the time of taking up the vine, when there was no possible chance of its restoration.

SECTIONIZING AND PRESERVING THE VINE.

The work of taking up and sectionizing the vine was begun the 17th of August, 1875; it was sectionized in such a manner that it could be set up again in its natural position. The object of this undertaking was to preserve this great natural curiosity. A small portion of each of the twenty large branches, and of each of the four large roots, were left on the trunk of the vine. These main branches at the first section near the trunk are marked alphabetically and run from A to T. Many of the large branches were so interlocked with each other that it was impossible to take them apart, or if separated to set them up again in their original order. These were bolted together wherever they crossed each other, and then cut in bolted sections of eight and one half feet in length, by five and one half feet in width.

These sections remain bolted, and can be set up precisely as nature had placed them on the vine. The remaining limbs were also cut in sections of the same length and numbered. The sections are connected by means of dowels and other irons, so that they can be connected on a trellis, and arranged so that eight, sixteen, twenty-four or thirty-two feet of the branches can be set up on one side only, or on all sides, as occasion demands or space permits. The entire length of none of the limbs will be used, as this would require too much labor and space. The trunk is left whole, and with the small portions of the limbs and roots attached is about ten feet long. The box containing it is an octagon ten feet in length by five and a half feet in width inside, in the clear, and is so constructed that it can be easily taken apart or put together. The trunk is permanently bolted by the roots to the base of the box, which, when the remainder of the box is moved, supports the trunk in the exact position in which it grew.

THE YOUNG MAMMOTH VINE.

This is now the largest living vine in the world. It is comparatively young, yet it almost equals the parent vine in size, and altogether in prolific bearing qualities. Though only about sixteen years old, it covers between eight and ten thousand square feet in area, and produces annually from eight to ten thousand pounds of fruit. Its diameter near the ground is over eleven inches, and three feet from the ground, where it divides into six main branches, it has a diameter of sixteen inches. It adds one thousand square feet of folinge and gains an inch in diameter of trunk per annum. The bunches of grapes weigh from one to four pounds each; they begin to ripen about the middle of August, and ripe grapes can be gathered for six months of the year, providing the fruit is protected from the rains and the ravages of birds and insects. Last year the grapes began to ripen August 15th, and continued in excellent condition till January 26th, when the last were taken off—a period of five and one half months, and yet the last grapes taken off were as delicious as those plucked in the early autumn.

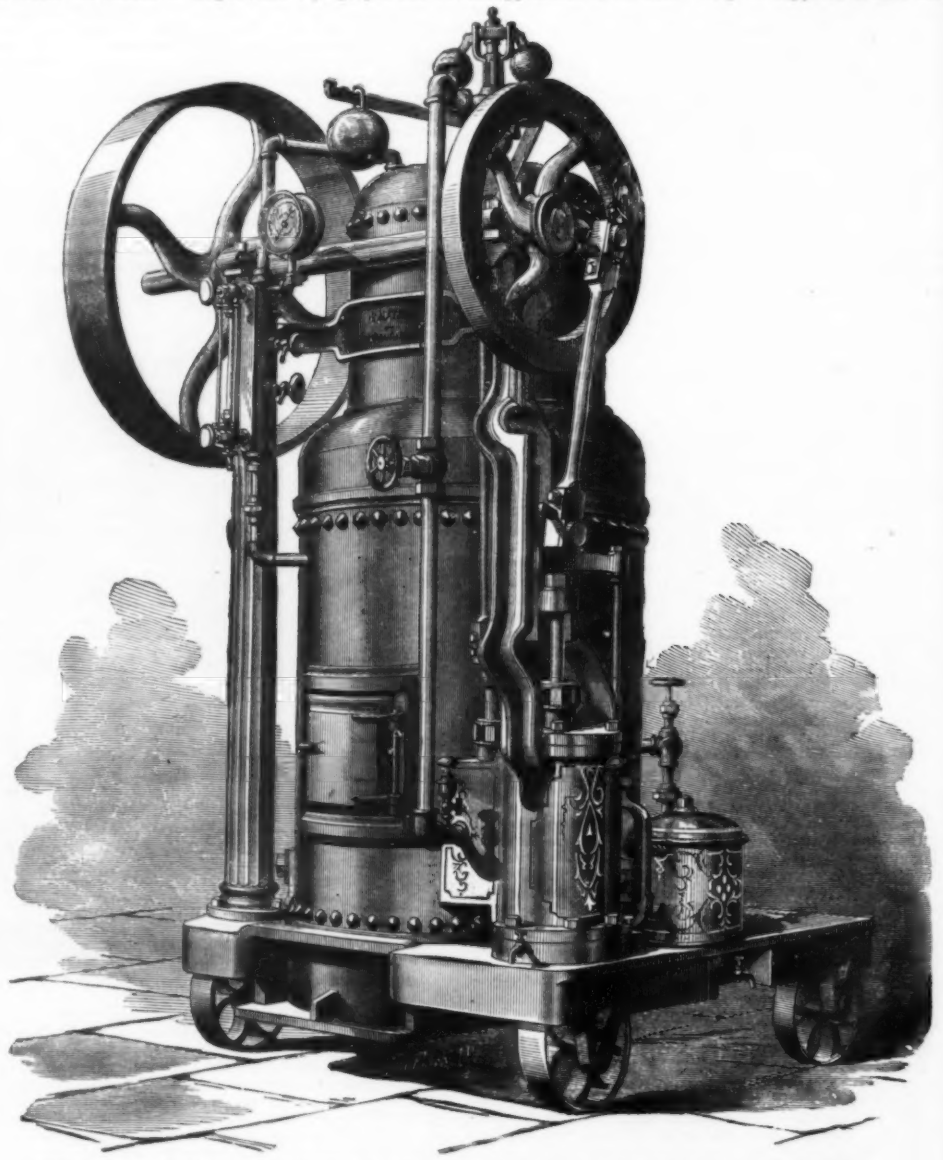
METHOD OF PRUNING.

The new canes are cut back each year so as to leave one or two eyes for the production of grapes. Along the outer edges some of the most vigorous canes are left from eight to twelve feet long, thus increasing the size of the vine at pleasure. The six main branches are trained on a trellis about nine feet high, these then into hundreds of minor ones, forming a dense and beautiful mass of foliage, under the shade of which there is ample space for several croquet-grounds. One side of this vine was formerly covered by the Spaniards with a dancing-floor for their fandangoes.

IRRIGATING THE VINE.

This vine stands on the edge of the same ditch which conveyed the water to the old vine, but was not irrigated nor was the soil cultivated nor fertilized till after it came into our possession, when the dancing-floor and other surroundings were at once removed, and the soil was cultivated and enriched, and partially irrigated on one side of it. It must be remembered that in southern California we generally have no rain from February till November or December. It has been learned by experience, however, that grapes need no irrigation provided they are properly cultivated during the rainy season and in the beginning of the dry season, because the soil will then retain moisture sufficient without rain, hence irrigation is now generally abandoned. We quote the following language from Hyatt's Hand-Book of Grape Culture: "Mr. Miller, of Solano County, some years since engrafted the best and most delicate varieties of the foreign grape upon his Mission stocks with the utmost success, and yet, in answer to our question, Mr. M. frankly admitted that he thought it a mistake to do away with the Mission grape." Hyatt then quotes the following practical remarks from Mr. Flint on this subject: "The Mission grape, which has already borne the test of eighty years of culture in this State (California) without one recorded season of failure, still maintains its prominence both as a dessert and wine grape. Indeed, by reason of its richness in grape sugar, the abundance of its juice, the evenness of its time of ripening, and the ample, broad, thick foliage which enables it to withstand our dry, hot days, and during the succeeding cool nights absorb from the atmosphere an ample supply of moisture to feed its prodigious loads of fruit, this variety is almost without a peer for extensive vineyard cultivation." Mr. Hyatt, under the title "California Varieties," says, "We have seen at the commencement of this part of our subject how great a favorite this Mission grape is in California. The Mission grapes are generally classed as two different kinds, the Los Angeles and the Sonoma, or the northern varieties in reality. The difference of soil and climate may be sufficient to account for the slight difference in the appearance of the fruit. They are supposed to have been introduced into California by the Jesuit missionaries from Spain. They very much resemble a grape seen in Morocco. The Los Angeles, Cal., variety has a somewhat heavier bloom than that known as the Sonoma, and bunches of the fruit sometimes seen in the San Francisco market weigh from five to seven pounds."

Mr. Hyatt says: "It has succeeded very well in some of the Eastern States. The grapes from some cuttings from Los Angeles grow in the open air at Albany, and some at Buffalo, N. Y., are not quite so large as those sent from California, but are of fine flavor."



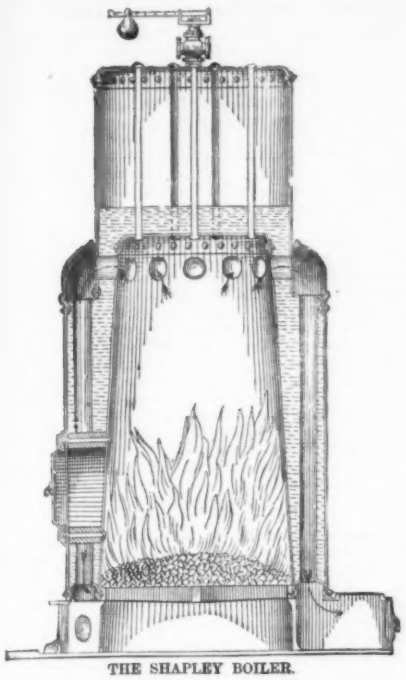
THE INTERNATIONAL EXHIBITION OF 1876.—THE SHAPLEY ENGINE AND BOILER.

PORTABLE ENGINES AND BOILERS AT THE EXHIBITION.

OF the Shapley portable engines, whose design is shown in the accompanying illustration, there are 3, 5, 8, and 12 horse-power engines in Machinery Hall of the Centennial, the 8-horse one being at present in the boiler-house, where it is intended to test the small engines.

In the Shapley engines, the frames standing off from the boiler are freed from the strain due to the difference in the amount of expansion between the boiler and the frames. The general arrangement of the parts of the engine are upon the locomotive plan, the wearing surfaces being large and well-fitted; the connecting-rod straps being held by bolts, and the brasses being left brass and brass, enabling the engine to run

very quietly at a high piston speed. All the working parts of the engine are easily accessible. The boiler, which is shown in section in Fig. 2, has a conical fire-box, which greatly increases the effectiveness of the surface of the side area and concentrates the heat in the upper part, whence it passes through the horizontal cross-tubes shown in Fig. 2, thence following the course denoted by the arrows down through the vertical tubes and into the hollow base, at the rear of which it finds egress into the flue. Thus, by a very simple arrangement and construction, the boiler is given a return flue and one that is very easily got at for the purpose of cleaning the flues or for repairing them when necessary, while a comparatively large quantity of useful heating surface is provided in a small amount of space, with the result of economy in the consumption of fuel.



THE SHAPLEY BOILER.

The jacket shown in Fig. 2 is composed of two detachable sections secured to their places by the bolts shown, so that by removing the bolts and the jacket, access is given to a short brush or tube-cleaner for the vertical as well as the horizontal tubes.

To avoid the danger incidental to the passage of sparks with the products of combustion, the vertical tubes prove very efficient, the sparks falling into water with which the hollow base is supplied.

The boiler is made of the best of material, and is well stayed on the crown sheet of the fire-box, and as all the heating surface is well below the water-line, there is very little chance, with ordinary care, of the plates, tubes, or crown sheet getting burned. The engine has a neat as well as a substantial appearance; the finish is all that is required, while the fitting of the various parts is excellent. J. R.

STEAM-BOILERS AT THE EXHIBITION.

THE Babcock and Wilcox boiler, shown in the accompanying engraving, is in operation in Machinery Hall at the Centennial. It contains 14 rows of vertical and 7 rows of horizontal tubes, the former numbering in all 14 and being 4 in. in diameter and 4 ft. 4 in. long, and the latter numbering 98 and being 3½ in. diameter and 16 ft. long; the drum for the steam and water being 12 in. in diameter and 8 ft. 4 in. long, providing 6 cubic feet of water and 12 square feet of heating surface per horse-power.

The tubes are lap-welded wrought-iron, and are connected at the ends by means of a steel casting, the holes for receiving the tube ends being bored and the tube tightened by an expander. The openings at the ends of the tubes are closed by hand-hole plates having a ground joint, so that the use of packing is entirely dispensed with.

The products of combustion ascend between the tubes into a combustion chamber, whence they are deflected down between the tubes again to rise once more between the tubes ere passing to the chimney. Connected at the lowest end of both the horizontal and vertical tubes is the mud drum, which is, therefore, not affected by the circulation save to act as a receiver of the impurities of the water which are conveyed by the circulation to the mud drum.

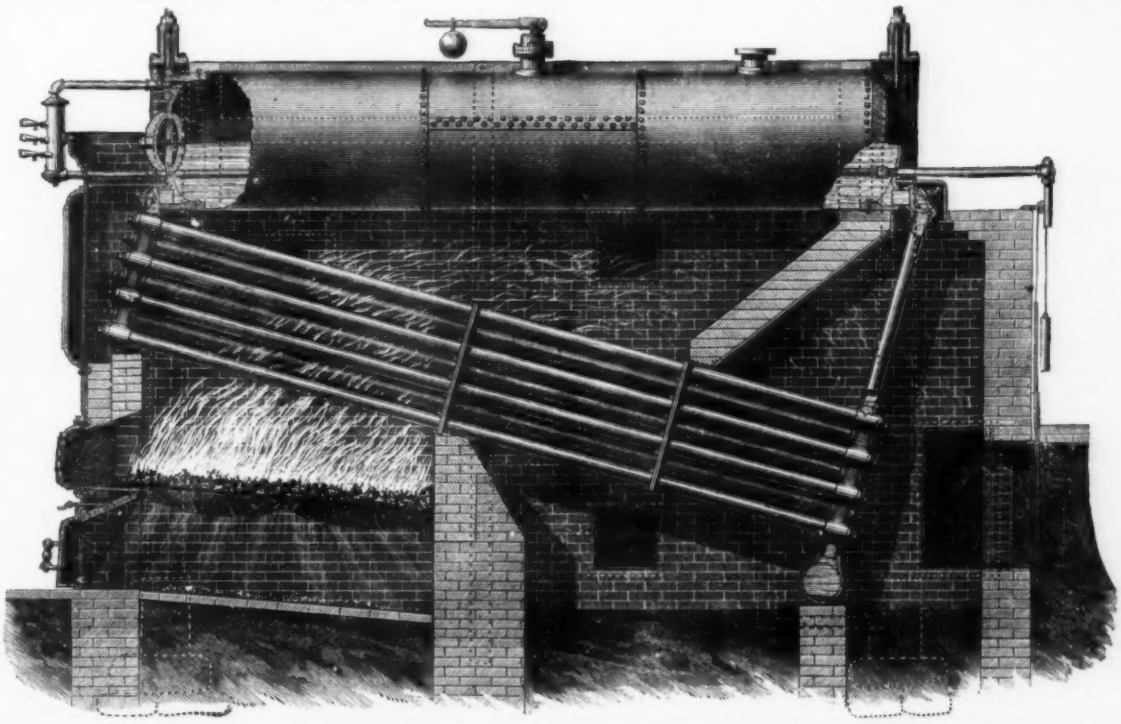
The water inside the tubes as it is heated tends to rise toward the higher end, and as it is converted into steam, passes through the steel casting above referred to, thence through vertical tubes into the drum above the tubes where the steam separates from the water, and the latter flows back to the rear of the drum down through the vertical tubes and thence through the horizontal tubes again into the steam and water drum, where it gives up its steam as before, thus keeping up a continuous circulation and affording a large surface through which the steam may disengage itself from the water and thus prevent the boiler from foaming, and enabling it to supply unusually dry steam.

Every part of this boiler is very accessible; the hand-holes at each end of the tubes, both vertical and horizontal, are the full size of the tubes, thus permitting free access for cleaning purposes; there are man-holes affording access to the steam-drum and bonnets at the ends of the mud drum, while access for cleaning soot from the outer surfaces of the tubes is obtained by means of doors in the side walls.

The seams of the steam drum are double riveted longitudinally, and the whole of the workmanship evidences care in the manufacture. Boilers of the same design are made by this firm of steel, if required.

In erecting the boiler, it is suspended entirely independent of the brick-work from girders resting on iron columns, so that the boiler is entirely erected before the brick-work is built up, which is done to avoid any strains from unequal expansion between it and the enclosing walls, and to permit the brick-work to be repaired or removed if necessary, without in any way disturbing the boiler, which is an object of great importance.

The space occupied by the boiler is small compared to its capacity, and it has a neat and tasty appearance.



THE INTERNATIONAL EXHIBITION OF 1876.—THE BABCOCK AND WILCOX BOILER.

THE INTERNATIONAL EXHIBITION OF 1876.

No. 19.

AMERICAN IRON AND STEEL IN THE MAIN BUILDING—CONTINUED.

THE Fort Pitt Iron Works, of Pittsburg, Pa., exhibit a fine assortment of hammered cast steel, machinery and spring steels, and iron and steel plough beams. Like nearly all their competitors, too, they show specimens of their product which have been subjected to every imaginable distortion while cold, in illustration of its tenacity and toughness. The extent to which this method is resorted to by exhibitors shows that iron and steel masters attach a greater value to toughness in these metals than has been the case in the past, and which its importance deserves.

The Trenton Iron Works, Cooper, Hewitt & Co., founded by Peter Cooper, makes a magnificent exhibit of coal, ore, pig, and wrought-iron, Martin steel, beams, girders, angle-plates, and kindred work. Fractured specimens of fibrous bar, which are very fine, specimens of iron puddled for grain and for fibre, and fine pieces of Martin steel from ½ in. to 3½ in. diameter are shown. One of their specialties—chain cable—is shown in large variety; and one specimen, with links 9 x 15 in. of 2½ round iron, weighing 50 lbs. to the link, is notable. The cable for the Pacific mail steamer "City of Pekin" was made at this establishment, from 2½ in. iron, and is one of the largest ever made. They exhibit a rolled H girder with central web 15 in. wide and flanges of 6 in., weighing 200 lbs. to the yard, which is a very fine piece of work. They also show models of the "Pernot" puddling and steel furnaces used at their works, and several curiosities, among which are a pig, cast at Ringwood Iron Works in 1772, and a stove plate from the same place, made in 1756. In a long glass case, made with iron sash, are shown coal and ores used in, and the products from, 51 blast furnaces, situated in the Lehigh Valley, and which furnish the raw material for the works at Trenton. Among these are some shot and shell cast during the Revolution, at the Durham Iron Works, which are now a part of this concern. There are some very fine specimens of flange forging, and the usual assemblage of pieces of iron and steel, twisted, punched, stretched, and otherwise distorted while cold; an ingot of steel 9 x 9 in., showing a magnificent fracture; and a piece of refined pig-iron, which required 16,700 lbs. to rupture it by tensile strain. This is, altogether, one of the finest and most comprehensive exhibits in this line.

Moorehead & Co., of Pittsburg, Pa., exhibit sheet and galvanized iron, and stamping iron for hollow ware, with specimens of the work made from it.

William Clark, of the same place, shows a very fine assortment of hoop and band iron of excellent quality. Whitaker & Skirm, of the Star Chain and Nail Works, Trenton, N. J., present polished chain work of small sizes, and angle and other forms of iron work, in considerable variety.

Van Alen & Co., Northumberland, Pa., show an excellent assortment of nails; Carnegie Bros. & Co., Pittsburg, Pa., exhibit all shapes of iron work which come from the rolls for use in engineering structures. One magnificent piece of special rolling is that of a short section of a wrought-iron coupling used in connecting the steel tubes in the arches of the great St. Louis bridge. Its form is that of a semi-cylinder of 16 inches inside diameter, with a foot-like rib on either edge 3½ inches wide, the thickness of the cylinder being 1¼ inches.

Wilson, Walker & Co., of Pittsburg, Pa., exhibit some exceedingly fine work in shape of railway-car couplings, buffers, the Miller hook coupling, and other railroad forging.

One of the very few among American exhibitors who present the inquirer with such important facts and figures as are derived from actual tests of their goods, is the Otis Iron and Steel Co. of Cleveland, Ohio, makers of boiler and tank plate, spring and machine steel; and among these are the following. Flat bar steel, breaking at 71,900 lbs. tensile stress with 50 per cent reduction of section; round machinery steel rod, 72,400 lbs., with section reduced 41 per cent; half-inch steel plate, subjected to the bulging test, cold, bulged to a hemisphere 9 inches in diameter, with reversed bulges in the same plate, all without rupture. They show a piece of flange forging from their steel plate from a 1-inch hole to 15 inches diameter, with flange 8 inches wide—a most excellent test, and well executed.

The Union Iron Co. of Buffalo, N. Y., exhibit Lake Champlain ores and pig-iron, with rails, girders, angle irons, etc., made from them, and some pieces of specular hematite ore from Lake Superior, containing 65 per cent of metallic iron.

The Cambria Iron Works, Johnstown, Pa., have a very extensive exhibit of pig-irons, blooms, piles, etc., illustrating the progressive stages in the manufacture of rails, steel ingots in their various stages for the same work, and an enormous pile of both steel and iron rails of all patterns, kinds and weights per unit of length. They show a diagram giving the deflection and permanent set of their rails arranged for supports 4 feet apart, from which that very satisfactory kind of information so much sought for regarding the character of work and materials may be obtained. They show also some very conclusive instances of self-imposed or accidental tests to which their rails have been subjected, such as a pair of iron rails which had bridged a gap in the road, resulting from a washout, 12 feet wide and of the same depth, and had safely sustained the passage over it of a 25-ton locomotive and a train of 7 cars; a length of iron rail which had been eleven years on the north main track of the Pennsylvania Railroad, near New-Florence, Pa., on an up grade, had lost but 5 per cent of weight in that time, and is in better condition than many rails now in use.

Stewart & Co., of South Easton, Pa., show their manufacture of wire in all sizes and shapes. The Passaic Rolling Mill Co. of Paterson, N. J., have a very unpretending case, but a most excellent exhibit of T, angle, and other bars. The Enterprise Iron Works, Youngstown, Ohio, make a showing of hoop and band iron of extremely fine finish upon the surface

The Woodstock Iron Co., of Anniston, Ala., make a magnificent display of their manganiferous and other iron ores and

pig, giving analyses of each, which will fix these productions as of more than ordinary value among iron men.

The Globe Rolling Mill, of Cincinnati, Ohio, shows small bar iron, nail, rod, etc.; and the Lackawanna Iron & Coal Co., of Scranton, Pa., present samples of magnetic ore specially adapted to the production of Bessemer steel, with analyses showing from 53 to 57 per cent of iron, and but from .038 to .040 per cent of phosphoric acid. One specimen from the "furnace" vein shows that ore to be entirely without phosphorus. Rolled bar-iron from this ore stands a tensile test of 70,000 lbs. to the square inch of section.

The Co-operative Steel and Iron Company, of Danville, Pa., exhibit steel and steel-headed rail; the Peru Steel and Iron Company, of Peru, N. Y., show magnetic iron ore and bars, and blooms made from them, as well as samples of plumbago; from Clintonville, N. Y., charcoal and shingled loops from the "Palmer" ore; nail rod and heavy rod from Peru billets. The Carrick Furnace, Pa. (R. M. Shalter), and the Black Diamond Steel Works (Park Bros. & Co.), have a very fine display of cast bar steel, homogeneous cast-steel plate, and, among curious specimens of flange forging, have a five-pointed star, about 3 feet across, with the edges flanged down 3 inches deep, and a diamond-shaped opening in it similarly flanged. The remarkable feature in this piece of work consists in the fact that all the points and angles of the star are brought up sharp, and the whole is done symmetrically throughout.

The Wayne Iron and Steel Works, Pittsburg, Pa., make a fine exhibit of their ores, pig irons, puddle balls, blooms, steel ingots, and very finely rolled bar steel. They also show fine specimens of flange forging, and sheets subjected to the bulging test.

The Washburn & Moen Manufacturing Company, of Worcester, Mass., make one of the most extensive and complete exhibits in this building. They show steel and iron wire in all shapes and for all known purposes; and as it will be interesting to many to know of the multitude of uses for this form of iron and steel, I will mention some of them. There are tempered-steel wire for ramrods; telegraph wire; tinplated, galvanized, and coppered wire; wire made especially for belt hooks; square, triangular, and reed wire; hexagon, half-round, flat, and other forms of section; gun wire; concave cable-screw, hair-pin, and staple wire; hoop-skirt, broom, and piano or music wire. They exhibit also the iron in all stages of progress, from the ore to the finished product. This is one of the oldest and most extensive establishments of the kind in the world, and its exhibit is in full keeping with its reputation and importance.

Allan Wood & Co., of Philadelphia, and W. D. Wood & Co., of Pittsburg, Pa., and of the McKeesport Iron Works, make a very fine exhibition of their various well-known grades of sheet and plate iron, both plain and galvanized, as well as a most excellent showing of their patent planished sheet iron. This latter will rival in finish of surface the famed Russia iron. In this connection they exhibit a very fine specimen of a locomotive jacket, and several others for cylinders and similar work. The Corrugated Elbow Company exhibit their now celebrated work in connection with this exhibit, as well as the machines upon which this very desirable article is made. These companies exhibit some remarkable specimens, in shape of sections of boiler tubes, made from their XXX B.B. brand of iron, which have been flattened cold, endwise of the tube, in which the peculiarly sharp buckling and distorting of the metal must be a very decisive test of its toughness and strength.

Miller, Metcalf & Parkin, of Pittsburg, Pa., make an excellent display of their special steel, known as the "Crescent." They take a novel but most excellent method of exhibiting the commendable character of their steel, by placing on exhibition voluntary contributions from their customers, in shape of the special manufactures of each, accompanied by testimonials as to the value of the steel from which they are made. Among these are taps and dies, shoe dies, stonecutters' tools, oil-well tools, punches and dies, envelope cutters, mill spindles, planer knives, corset springs, and hardened steel rolls, such as are used in the mints of the United States and Mexico; railroad track tools, fine machine tools, dental instruments, moulding machine cutters, cutlery, clock springs, tools for turning chilled rolls, and others considered as putting the material to the severest kind of duty. They show one tap with square thread of 6 inches diameter and about 30 inches long, now in fair condition, which has tapped out, on work for the St. Louis Bridge, the following: 120 steel nuts 12¼ inches long, 40 of the same 9 inches long, 48 iron nuts 12¼ inches long, 6 of iron 9 inches long, 155 feet of thread in steel castings, and 62 feet in other wrought-iron work—which will be regarded as a most extraordinary performance by all who are familiar with the wear and tear upon a large tap when used upon steel.

Messrs. F. Prince & E. L. Bullock show a very interesting model of an anthracite colliery, with the superincumbent strata removed, discovering the workings in the "Wharton" vein, near Audenried, Carbon County, Pa. It is on a scale of 30 feet=1 inch.

The Union Steel Screw Company, of Cleveland, Ohio, exhibit a large variety of their steel blanks and wood screws, of all kinds, with flattened and distorted specimens to show toughness. They also exhibit plates of their steel, bulged cold, ¼ inch thick, simulating a base-ball player's cap; also a large exhibit of other work, such as sheet and galvanized iron, steel horse-shoes, Bessemer steel wire, Siemens-Martin steel boiler-heads, and, most curiously, driving-whips, made of one piece from Bessemer steel.

The Adirondack Iron and Steel Co. show cast-steel lathe spindles, "frogs," crank-pins, with tool, spring, shear, and machinery steels.

In an unpretending little show-case an exhibit in this line is made of the Henderson Patent Process for iron, which is the only one in the American Section which can be said to give a complete and exhaustive record for their wares from the results of actual test. In this case is given a large number of specimens from all the grades of iron made by this process, all subjected to test by Mr. David Kirkaldy, and tables of the authenticated results. Their process consists in placing in the bottom of the ordinary puddling furnace a pulverulent mixture of fluorspar and titaniferous and magnetic ores of iron, running the molten pig-iron on top of it, boiling for about one hour, and then balling in the usual way. The decarbonization of the pig-iron is effected by its combination with the oxygen of the ores, and the purification is said to be accomplished by the fluorspar, which makes some kind of a combination with the phosphorus particularly, such that it must pass off in the gaseous form, as it is not afterward, by analysis, found either in the iron or the slag. It is said to be the only process known by means of which any considerable percentage of phosphorus can be completely eliminated from the ore, so as to leave the resulting product free from that substance. They give some very extraordinary instances of this, with specimens of both the ore and the iron, with the analyses of both. A specimen of Govan "glazed" pig, condemned as unfit for any purpose, and containing nearly 1.5 per cent of phosphorus and 5 per cent of silicon—after purification and rolling into bars—gave way under tensile test by Mr. Kirkaldy at 66,540 lbs. to the square inch, elongated 62 per cent, and contracted in section 45.5 per cent. They show many other equally satisfactory experimental examples in illustration of the value of their process, which will be of much interest to all engaged or interested in the iron and steel industries; and they are certainly to be commended for the thorough manner in which they have placed their exhibit before the public, particularly as the process was first tried no longer ago than last September.

With this long list of American iron and steel exhibits, it will be readily admitted that, for extent and variety, as well as value to the mechanic arts, of the material and products shown, there has never before been seen any thing approaching it under one roof; and, upon the most superficial examination of them, no one can fail of the conviction that a great future awaits this country in this most important branch of human industry.

J. T. H.

WATCH-MAKING AT THE CENTENNIAL.

By JOSHUA ROSE.

THERE is no feature of the Centennial which appears to be more attractive to the general visitor than constructive mechanical processes, nor is there any, perhaps, which is more really instructive. By watching a single operation, performed either by hand or by machine, one is rather amused or interested than instructed, but when we can follow a process of manufacture from its commencement, we are more deeply interested, as well as instructed, and, furthermore, the knowledge gained becomes so much more deeply seated, that it is scarcely likely to be readily forgotten. In the Government Building, the exhibition of the processes of cartridge and rifle-barrel making is far better attended than any other of the numerous and interesting exhibits, and next to the above, in point of interest, stands the envelope-making machinery. In Machinery Hall, the band-sawing machines, the envelope-making machine, the Jacquard loom, the needle-making machine (which we shall describe in a future issue), and the subject of this article, the watch-making machines, are so continuously thronged that one has to await his turn to inspect them.

The watch-making machines are exhibited by the Waltham Watch Company, of Waltham, Mass., who have branch houses in Chicago, Boston, and London, as well as the New York store. The processes exhibited are the manufacture of the screws, wheels, pinions, jewels, and damaskeening the plates.

The screws are made as follows: The wire used is polished wire, cut in lengths of about 12 inches, the diameter being that required for the size of the screw-head. A length of wire is passed through a hollow spindle, answering to the spindle of a lathe-head, and is held by a chuck whose jaws are tightened by a spring movement. Upon placing a length of wire in the chuck, which is done by hand, the first operation is to cut off the end of the wire so that the first screw will be of the proper length. The next operation performed by the machine is to turn down the plain stem ready to be screwed, and this is performed by a simple square-nosed turning tool, which, by a cam movement, advances into the work, cutting the whole length of the plain part of the screw, and advancing toward the centre of the wire until it is turned down to the proper diameter, whereupon the tool recedes, and a spindle answering to the tail-stock spindle of a lathe, but provided with a pair of dies in the place usually occupied by the dead centre, advances automatically, and as it meets the screw end it revolves, while the wire is held stationary, thus cutting the thread upon the screw to the requisite distance, and then the dies rotate backward and recede, leaving the screw free; the chuck then again grips the wire, and revolves it, while a cutting-off tool advances and cuts the wire at the distance necessary to leave the requisite thickness of screw-head, very nearly through. The cutting tool then recedes, leaving the revolving screw very nearly severed from the wire, and a cam arm with a suitable attachment upon its end swings over, and taking hold of the screw, breaks it from the wire, severing the small section of metal left by the cutting-off tool, which section has but little more strength (on account of its small diameter) than is necessary to support the weight of the screw. The arm carries the screw to a revolving cutter, or milling tool, which cuts the slot in the head; this being done, the cutter lifts, by an automatic movement, out of the way, and a pin moving horizontally forces the screw out from the holding device in the cam arm, whence it falls into a trough provided to receive it. The position of this trough is such that the cuttings, as well as the oil and screws, fall into it, but being perforated, the oil drains off and leaves the screws bare. During each of these operations, the oil is fed by pumps, and the whole of the movements are performed by the machine itself, to that the operator, having nothing to do but keep the machines supplied with wire, can attend to ten of them, each making 5000 per day. The smallness of these screws may be appreciated when it is stated that one of them weighs about the nine thousandth part of an ounce.

The screws are then hardened, and the next operation is to round the end face of the head, preparatory to polishing it. This is accomplished by revolving a piece of Arkansas oil-stone at a speed of about 1100 revolutions per minute. The stone is in the form of a tube, about 2¼ inches diameter and ¼ thick, and is carried on the end of a revolving spindle, similar to that of a lathe-head, and held by a similar head and bearings. The screw is picked up with a small pair of pliers, and put into a small clamp provided in a rest (similar to a slide-rest), and is then brought into contact with the outside corner or edge of the revolving oil-stone, which is freely supplied with oil, while the screw is revolved and moved laterally, so that the stone cuts the head rounding and true. It is astonishing to observe the precision with which the operatives, who are, with two exceptions, girls, will pick up these miniature screws and place them into the diminutive hole in the chuck, an operation more delicate than threading an ordinary needle, and yet it is performed with comparative ease, and apparently without requiring much attention or effort, and we are informed by Mr. Thomas, who superintends the operations at the Centennial, and to whom we are indebted for the excellent facilities afforded to us for our investigation of the operations, that the latter are too delicate to be so successfully performed by male labor. The next process is polishing the heads so that the tempering of the screws will leave the heads a bright, clear blue. This is performed with a wooden lap of the same shape and revolved in the same manner as the oil-stone described above, but running 800 revolutions per minute. The polishing material used is Vienna lime and oil, the screw being brought into contact in this case with the end of the lap, the screw being operated as before. The Vienna lime is applied to the lap on the blade of a knife. The chuck holding the screws is in both these two last operations operated by a crank movement. When the polishing is completed, the screws are cleaned by the application of a piece of stem pith, such as is found in some kinds of wood.

CUTTING THE GEARS OR THIRD WHEELS.

The pinions called third wheels are sent to the Exhibition in the form of blanks, and are cut as follows. The machine is provided, after the form of an ordinary gear-cutter, with two mandrils, one being in the machine, while the other is being supplied with blanks. These mandrils are hollow, and have several splits running along the part on which the pinions are held, thus forming what may be termed a spring mandril. Twenty-five blanks are placed close together on the mandril, and are tightened by a thumbscrew. The mandril is then put into the socket of the machine. The cutter used is similar to a turning tool, but is V-shaped on the back to insure its standing in the proper position—that is to say, with its face at a right angle to the faces of the blanks upon the mandril. It is fastened in a revolving head or mandril, which makes about 8000 revolutions per minute, and which is adjustable in height to accommodate different diameters of wheels, the mandril holding the blanks being stationary, in height under all conditions. This mandril feeds along under the cutter in such a direction that the pressure due to the cut tends to force the work back from the cutter, which prevents the cutter from breaking, as it otherwise would do. When the cutter has cut one groove through the whole twenty-five blanks, the mandril holding them recedes automatically, and rotates the distance necessary to leave the sufficient width of tooth, when the mandril again advances beneath the cutter, the whole operation being continued until all the teeth are cut, when the machine stops itself.

MAKING THE PINIONS.

The blanks of which the pinions are made are short pieces of wire, and the first operation performed upon them is to chuck them in a universal chuck fastened to the spindle of the lathe; the face of this chuck is bevelled off, so as not to obstruct the vision of the operator. The blank is turned down first at one and then at the other end, to nearly the required size, a tool and hand slide-rest being employed for the purpose—the rest coming against a stop to regulate the diameter to which the tool will turn; a cutter fixed to the tail stock spindle faces off the ends and covers them, after cutting them off to the proper length. Another operator and machine finishes the turning; the process just described being the roughing out or blanking. In this second operation, the attendant has merely to put them in and take them out of the lathe, which takes but an instant; the lathe tools, operating automatically, cuts the parts the proper diameters and lengths, leaving the work clean, bright, and true.

CUTTING THE PINION TEETH.

The pinions are now ready to have the teeth cut in them, which is done as follows: The delicacy of this operation renders it impracticable to cut out the teeth at one cut, or with one cutter, because that would entail that the pinions be held more firmly than it is practical without bending or, at least, springing them. The machine is therefore provided with a revolving head containing three spindles, each provided with a milling cutter. The first is a thin one, cutting a groove much thinner than the finished size, and lifted from contact with the pinion during the back stroke, which greatly preserves the cutting teeth. The second cutter is a little thicker, and operates the same as the first; while the third cutter merely takes a light finishing and very true and clean cut. Oil is freely supplied to all three of the cutters. One machine will cut two hundred pinions a day, and one operator attends to two machines.

GLOSSING THE PINIONS.

The next process is to gloss or polish the teeth of the pinions—the glossing material used for this purpose being a fine oxide of iron. The pinions are picked up by pliers—in this as in all the former operations—being too small to be handled by the fingers, and are placed so that the stem on each side of the teeth lie in V bearings, open at the top. While in this position a lead lap, operating reciprocally and making about 400 strokes per minute, and supplied with the glossing material, traverses along the grooves of the teeth, imparting to them a high polish. Every second or so, the carriage holding the pinions drops a short distance, and a small steel arm moves the pinion, so that when the carriage lifts again, the lead lap will operate in the next tooth-groove. This process is continued until the teeth are glossed to a superior polish, when the pinions are taken out, and cleaned by brush-wheels revolving at a high speed. The staff-polishing is performed by placing the pinions in a small head corresponding to a lathe-spindle revolving about 3500 times a minute. At the back of this spindle stand two emery-wheels of the same tubular form as the oil-stone described as used in the process of screw-head rounding. These two emery-wheels revolve with the plane of one at a right angle to that of the other. The polishing-wheel is upon a separate arm, and is circular and conical, with a flat place on the largest diameter of the cone.

In operation, this polishing-wheel, while revolving at about 4000 revolutions per minute, is first brought into contact with the revolving emery-wheels, which grind sufficient off the end face and diameter of the polishing-wheel to bring up the corner quite square, and thus enable it to polish the pinion staff close up to the teeth of the pinion. It then swings over to the pinion-staff while the latter is being revolved at a high speed, and traverses along it while supplied with rouge.

After the polishing-wheel has done its duty, it passes over to the emery-wheels to get the corner made sharp again; it having become slightly rounded during contact with the corner of the staff, formed by its junction with the pinion-teeth.

The finishing of the staff is performed by Vienna lime mixed with alcohol, and applied to a small piece or slip of wood, which is operated, as a file would be, against the staff, imparting to the work a very fine and superior polish.

The next process is that of cutting a pivot on the end of the staff, and rounding off the edges with a very fine small file; the conical point of the staff is finished by a steel lap in the shape of a cross, and having the edges of the laps bevelled off to the necessary taper. As the lap moves reciprocally the cone side of one of the edges rests upon the end of the staff; while another edge of the lap rests upon a jewel mandril, standing in the position of a dead centre in a common lathe; thus the lap is kept in the exact proper position to ensure that the work shall be all lapped exactly alike. The lap is supplied with Vienna lime and alcohol, the finishing touches being imparted with the same materials applied upon a wooden slip.

The pinions are now ready to be cupped—that is to say, to have a small cupped recess turned in one side beneath the

diameter of the teeth on the side face, to serve to hold the oil, which operation is termed "turning under." The lathe is kept running continuously; the pinion being revolved by friction produced by the back lathe centre being held up by a spiral spring to put a pinion in the lathe; the back centre, which is in this case a cup made to fit the staff end, is pulled back against the force of the spring, and the pinion being placed into position, the spring is let go, and pressing the pinion against the running cup-chuck, the two revolve together. The operator performs the turning under with a graver by hand, using an eye-glass during the operation.

HUBBING THE THIRD WHEELS.

The third wheels being made from sheet brass have to be provided with a hub on one side, which is done as follows: The wheels are first bored quite true with the teeth and of standard size. The blank hubs are made from brass wire, and have a small pin turned on one side, the other side being capped or recessed to facilitate the riveting. The press on which the hubbing is performed has a small hole drilled in the horizontal face, which hole stands exactly central beneath a vertical plunger or spindle, which operates in an upright guide. The hub is placed beneath the plunger, and with the pin placed in the small hole, which thus keeps the hub true, the wheel is then placed on the hub, against the cupped side of which the end of the plunger is allowed to rest. A few light blows delivered by a hand-hammer upon the top end of the plunger causes it to rivet the hub into the wheel. The wheel is next chucked in a lathe, and the end of the hub is faced off, and is next drilled, and the diameter of the hub is then turned tapering or conical, the burr left on the end of the cone by the turning process being removed by the facing-off tool first used. On the other side, the wheel is slightly countersunk. The wheels and pinions being turned quite true, and all the polishing done, the two are put together by a press, the pinion being forced into the wheel in what is termed a staking-press.

THE JEWEL WORK.

The jewels come to the Exhibition cut out in small small disks, and with a small recessed conical centre in them, and the first operation is to chuck them. The lathe-head is provided with a small mandril, having its end, as well as its diameter, very true. A small spirit-lamp is held beneath the end of the revolving mandril, to which a little cement is applied. By holding against it a small stick of the same, the jewel disk is then applied to the end of the revolving mandril, to which it will adhere, care being taken to leave the face containing the small recess outside. Then into this small recess is placed the point of a piece of steel wire, and the operator, by this means, moves the jewel upon the chuck, until it runs true—an operation apparently difficult, but which the attendant performs in an instant. The jewel is then turned by a diamond tool supplied with water, and held in a small rest moved by hand; but the direction of the movement is guided by the rest, which thus ensures that the jewels shall be all of one size and shape. The cupping necessary to one side of the jewel to retain the oil is performed by a diamond tool in the tail spindle of the lathe.

The jewels are then ground by the application of copper tubes supplied with diamond-dust mixed with sweet-oil. Two copper grinders are used upon the outside, and one upon the cupped surface of the jewel. Then a similar polishing copper tube is used upon the outside with much finer diamond powder and oil, and one is used with the same material for the cupped surface, the jewels revolving during the operation at a speed of about 5000 revolutions per minute. The last operation is to drill the jewels, which is performed with a fine diamond drill, inserted half way from each side of the jewel to prevent the latter from chipping during the operation. The quality of the whole of the workmanship is very superior, and the display is one of those the most admired of any of the entries in the Exhibition.

STEAM BY THE POUND.

TO THE EDITOR OF THE SCIENTIFIC AMERICAN:

In the last number of the SCIENTIFIC AMERICAN SUPPLEMENT I find your correspondent J. T. H., in his article on the 'Corliss Engines at the Centennial Exposition," concludes by saying, "I have no doubt but that it will be found that they are producing an indicated horse-power on a consumption of not more than about 15 to 18 lbs. of steam per hour, and possibly less." As I never before heard the economy of a steam-engine expressed in such terms, and I don't understand its meaning, will you please to explain in your paper whether it is a misprint or a new term for expressing the relative economy of steam power? If the latter, will you please say what is meant by the expression—for instance, that a steam-engine is using "18 lbs. of steam per horse power per hour," and oblige yours, THOMAS KERSHAW.

NEW-YORK, June, 1876.

REPLY BY J. T. H.

In estimate of the efficiency of a steam-engine, above considered, the weight of coal consumed under the boilers, per unit of work done, or per I. H P. developed by the engine, can not be a correct exponent of the cost of such work or power, from the fact that the efficiency of the boiler is always a factor of the cost in coal. For instance, if, upon trial, the Corliss engines were found to be furnishing an I. H. P. on two pounds of coal per hour with their present boilers, and the latter were capable of evaporating, at the pressure and temperature used, nine pounds of water per pound of coal; if placed to receive their supply of steam from a set of boilers capable of evaporating no more than six pounds of water per pound of coal, the cost in coal would in the last case exceed that of the first, equal to 50 per cent of the first, or with the present boilers the power would be obtained at 33⅓ per cent less cost than with the new ones. In speaking therefore of the economic performance of an engine, it is correct only, and customary too, to compare the work done, or power developed, with the weight of steam admitted to the cylinder.

If the engine and boilers, as a whole, are under consideration, the weight of coal consumed per unit of work will correctly express the efficiency of the combination; but an efficient engine may be connected with an inefficient boiler, or *vice versa*, and the efficiency of neither boiler nor engine alone can be expressed in a ratio between work done by the engine and coal burned in the furnace of the boiler.

Strictly, the efficiency of an engine can not be exhibited in the ratio of weight of steam used to work done; but for all commercial considerations it is sufficiently accurate. The true measure of the efficiency of an engine is only shown in the proportion of useful work done to units of heat admitted to the cylinder, and as steam of different pressures contains different quantities of heat, the same weight of steam will not always correctly represent the same value. So that for a steam-engine with its boiler or boilers—as, for example, in estimating the economic performance of the steam machinery of a vessel, the economy is fairly represented by the cost in coal per unit of work. For a steam-boiler alone, the cost in coal per unit of weight of water evaporated under given conditions as to pressure carried, temperature of fuel, water, etc., will be equally correct; and for a steam-engine, the work done is fairly comparable only with the weight of steam used, and this steam may cost more or less in coal, according as the boiler furnishing it is more or less efficient. J. T. H.

PHILADELPHIA, July 7, 1876.

THE ROAD STEAMER "AMERICA" AT THE EXHIBITION.

TO THE EDITOR OF THE SCIENTIFIC AMERICAN:

GENTLEMEN: We notice in your SUPPLEMEN No. 26, dated June 24th inst., the severe strictures of your correspondent J. T. H. on the road steamer "America," strictures which, in charity to the author, we trust were made in ignorance of the following facts. Your correspondent could easily have ascertained, from our representative in attendance at the Exhibition, that our inventions consist simply of our traction wheel and steering apparatus, and that the present machine is exhibited solely to represent these particular features. It is the only one ever manufactured to test the merits of our patents, and any scientific critic who would expect a pattern machine to be without mechanical defects has forgotten the history of the steamboat and locomotive.

Notwithstanding these defects it has proven by actual work, in the presence of a committee appointed by the Franklin Institute, that we have a traction wheel of unquestionable merit, as is shown by their report and the certificate of Honorable Mention awarded us.

Since this trial we have greatly improved the steering gear, and claim that in steering by steam we have introduced a very important invention for handling road locomotives.

The delay in building new steamers after our improved designs has been caused by the inventor's want of funds.

The durability of the rubber-blocks can not be questioned, as the present machine has seen much service over all kinds of roads and streets, and there has not yet been an occasion for renewing a single block; therefore your correspondent's assumption, that from inability to withstand the wear and tear they had been supplanted on the steering wheel by "chunks of cast-iron," is unwarranted by the facts. Had your correspondent informed our representative of the purpose of his examination of our machine, we should cheerfully have shown him our improved designs, advised him of the opinion of some of our best engineers regarding them, and prevented him from making the blunder of stating that the rectangular boxes enclosing the rubber-blocks on the driving wheels and the caps on the steering wheel are of cast-iron, when on the contrary both are of cast-steel.

Yours truly, G. W. F.

THE NAYLOR ENGINES.

135 WISTER ST., GTN., PHILADELPHIA, June 3, 1876.

TO THE EDITOR OF THE SCIENTIFIC AMERICAN:

Allow me to thank you, in the name of the "People's Works," for the excellent notice your reporter J. T. H. gives of the engines constructed by Mr. Jacob Naylor in your SUPPLEMENT, No. 24, on page 374, but permit me also to correct a few statements which I find in that notice. The second sentence should read thus: "They all have the ordinary three port slide-valve with fixed point of cut-off, by the lap of the valve. The valve of the 18 x 36 inch cylinder is provided with a balanced ring applied in a manner different from the usual method, the subject of a patent by Cooper and Emery, and to which more particular reference will be made in the future."

Respectfully, J. H. COOPER,
Engineer of People's Works.

CENTENNIAL SUGGESTIONS.

IT is impossible to bestow a too-earnest tribute upon those praise-deserving gentlemen composing the Commission, who have given their thought and labor to the development of an enterprise, the mere external proportions of which it is difficult for even the intelligent observer to fully appreciate, while its internal value and influence are beyond calculation. The wise forecast they have shown, the indefatigable zeal, the indomitable courage, the unshaken confidence in results, are all to-day justified by the complete success which is surely crowning their efforts.

The qualities which have made such admirable preparation for the Exhibition are themselves among its noblest exhibits, and it is to be sincerely hoped will meet that hearty recognition on the part of the people which will be their most appropriate reward. It is a rare order of skill that can, in these times of depression, and without the aid of Aladdin's genii, call into existence an enchanted city, assembling therein specimen treasures from all parts of the earth, peopling it with a large and ever-changing population, maintaining in perfection the various departments necessary to modern metropolitan life, commissary, finance, police, and fire, affording every facility in telegraphy, postal, passenger, and freight transportation, and all this with such rare adjustment that no accident mars its history, and even inconvenience is exceptional. It is simply marvellous, and the man who permits some petty personal discomfort to belittle the grand achievement does not deserve to enter the gates.

It should be remarked that he who carries into the grounds an every-day spirit of selfishness will not derive the highest degree of pleasure or profit. *That* is an excellent thing to leave outside. If any of it gets in, an excellent way of exorcising it was hit upon by Mr. Lyman Abbott, when he suggested that on entering the Main Building at a side entrance the visitor should spurn all temporary allurements and go straight to the centre, and ascending one of the spiral stairways, gaze from the gallery upon the long perspectives of roof and aisle, and the wealth assembled beneath and within them. If he is suddenly conscious of a rush of emotions, and better still, of moisture in his eyes, these are good signs, and indicate that preparation of mind and heart appropriate to an exploration of the wonderful realm below. That nice admixture of humility and enthusiasm likely to affect a thoughtful man at this moment will render him teachable, and it cannot be too often repeated with emphasis that this is not a mere *show*, but an educational system upon a colossal scale, combining advantages for observation and study never before equalled at any one place. No nation has ever before had the doors of so magnificent a school of object-teaching opened to it, and our people should enter it not only with pride, but with the desire to gain its highest teachings.

When the inspiration of this first general view has been obtained, the visitor must be governed largely by the time at his disposal. If it be brief, he is to be commiserated, as he can then only glance hurriedly at such departments as may specially attract him, and these should be determined on in advance as far as possible, and even then the unexpected beauty of other divisions will sorely test his powers of resistance. Too much time amidst so many wonderful attractions is hardly possible; but if one have only the reasonable time afforded by from four to six days, it is full as well to give up the first one to drifting about, getting general ideas of the relation of the different buildings, the grounds about them, and the arrangement of the divisions within. This will not only enable him to decide upon the method for his later operations, so important to the highest enjoyment of the scene, but better still, it will acclimate him, so to speak, to the peculiar atmosphere of the place, and prepare him to gain both pleasure and profit in royal measure.

But whether for a short visit or a longer one, it is a *duty* to go, and ordinary reasons should not prevent any one.

Are you feeling poor? Deny yourself almost any thing else, and spend something there. You will feel the richer for the journey. If you are discouraged and depressed by the stagnation of the times, go there, and by contact with such marvellous evidences of the resources of modern life, and the wealth of the industrial arts, gather fresh energy and hope. You will return home with a broader view of things, and a higher sense of the grandeur of the age and the privilege of living in it. G. S. D.

THE INTERNATIONAL EXHIBITION OF 1876.

No. 20.

EXHIBIT OF THE RUSSIAN WAR AND NAVY DEPARTMENTS IN MACHINERY HALL.

ALTHOUGH the latest to arrive and place their articles for exhibition, by no means the least important or interesting display just now completed is that of the Russian Government in Machinery Hall, and perhaps that part of it relating to the engineer and artillery branches of the army and cognate parts of the Navy will equal in interest any thing of this kind in the building or the Exhibition. Owing to the late day at which the Russian Government decided to participate in the Exhibition, the space allotted could not well be gotten in one piece; their display is, therefore, made in two separate spaces—not, however, at any considerable distance apart.

Under the Engineer Department they exhibit entrenchment tools used by that corps and tool slings, with drawings showing their application; an elegant model of a pontoon bridge on a scale of $\frac{1}{10}$, built for purposes of illustration in the Nicolay Engineering School; a model of a pontoon bridge train with four kinds of wagons for the transportation of the bridge; model of a target shield as used at the Constantine Seashore Battery, in Fortress Cronstadt; a relief map of Sevastopol, showing the siege and defence operations of 1854 and 1855; some very fine specimen drawings, showing barracks, buildings, and construction of fortifications, with details of structures; drawings of telegraph train, showing the construction of wagons for a seventy-mile line; a description of the defence of Sevastopol (in French), by General Totleben; regulations for laying pontoon bridges, used for instruction purposes in the Engineer Corps, and other interesting objects.

Under the Artillery Department, the Imperial Russian Rifle Manufactory at Toola presents infantry rifles (muskets) used in the Russian army with bayonets as made in large quantities by machinery, taken at random to show the interchangeability of parts, together with all the requisites of the gun; a very finely constructed longitudinal section of the above rifle made in bracked pieces, showing very perfectly the mechanism and construction, and the different parts shown separately, just as they leave the special machinery by which they are made, to exhibit the perfection and exactitude of the latter. The rifle manufactory at Lestoresk, near St. Petersburg, exhibits the Cavalry and Cossack musket of the pattern adopted in the Russian army; the St. Petersburg Artillery Arsenal exhibits a mortar of 8-inch calibre, which has already withstood 400 shots, of which 300 were with a charge of 17 lbs. of prismatic powder under an initial pressure of 1350 atmospheres, and 100 with artillery powder which gives a pressure of 2000 atmospheres. This establishment also presents a 3-pounder mountain gun on a light iron carriage, loaded on four horses in lay figure, with Colonel Roubetz's system of harness and collar, also an 8-inch, 6-inch, and common shell for 3-pounder mountain gun, "circumfused" with lead.

The Ordnance Department shows an iron carriage for a 6-inch mortar on the system of General-Major Samenoff, which received a gold medal at Vienna in 1873, and a new iron carriage, with a cork buffer, for the purpose of relieving it from the strains coming from the recoil of the gun, on the system of Colonel Engelhardt. This carriage has withstood about 700 shots. Then the Ochta Powder Mills, near St. Petersburg, show samples of materials in the manufacture of powders, imitations of prismatic powder, and drawings of the machinery used in its manufacture, from the plans of Professor Wisnegradsky, and samples of powder made under the system of Colonel Winner. The St. Petersburg Cartridge Manufactory exhibits an excellently arranged series of parts of cartridges made in section, with the successive parts of case, cap and fusee, with a collection of the different parts of both percussion and distance fuses. In connection with the last is shown a very extensive and complete set of standard gauges, templates, measures, etc., used in verification of dimensions of the various parts of guns and cartridges. These gauges are claimed to be correct to within 0.0001 inches, and are made in one "precision" room for all small-arms factories in Russia, so as to insure interchangeable parts throughout.

There is also exhibited a "grooshkat," or portable travelling crane, for moving heavy weights in transhipment of goods at wharves, warehouses, depots, factories, and coal-mines, which is used by the Russian Artillery Department. It is the invention of Mr. N. Wonlarlarsky, and received prizes at the St. Petersburg Manufactory Exhibition, in 1870, and at the Moscow Polytechnic Exhibition, in 1872. Mr. Koorikoff, of St. Petersburg, presents a set of six harness for field artillery, for firemen's trains, and similar purposes. Colonel Tenner, of St. Petersburg, shows photographic representations of a lathe for wrapping bullets with paper; Mr. Gootkoosky, "mechanic," photographs of scales for verifying cartridges; Mr. Alexandroff, photographs of lathe for verifying cartridges in the breech; and Mr. Renta, "mechanic" (all of St. Petersburg), photographs and drawings of a lathe for mechanically dividing and stamping fuses.

Almost all of these instruments are exceptionally ingenious and valuable in their several applications, and I will endeavor, in future letters, to give you descriptions of them, with illustrations.

One of the most decidedly novel and efficacious inventions for purposes of war that has made its appearance for some time is that of the new "fortress gun." It is one of those decisive steps in advance which occasionally appears as a result of persevering and long-continued experiment and study, and is, I think, destined to seriously modify present engineering methods of offence against fortified positions. It is the invention of Major-General the Baron Hahn, in 1872, at about which time the Russian Government had begun to give its attention to the necessity for some such weapon. An artillery commission, appointed by the Government, for the purpose of investigating the subject, first required of the engineer department a detailed statement of what was required to best prevent the approach of an enemy by parallel and other engineering device. With their statement the commission then referred the matter to General Hahn, with the view of obtaining the exercise of his well-known ability in the production of something to meet the requirements of the case. Early in 1872 the primary principles of this weapon were decided upon by the General, and soon after the first trial of it was had, with marked success; not, however, without the discovery of defects in the weapon, which General Hahn at once set about to overcome. In March, 1873, a second model was completed for trial; but it was not until near the end of the summer of 1875 that the weapon, as finally accepted by the Government, was completed, tried, and approved. At the last trial the artillery commission tested the gun without the presence of General Hahn, and, as a result of their report, it has been adopted by the Russian Government. The essentials decided upon by the commission for the weapon were, that it should be sufficiently accurate to insure the striking of a target of one foot square at 1500 to 2000 yards, and, at the same range, to penetrate the devices used in defence of men in "parallel" advances, rifle-pits, etc. For the penetration of "sap-rollers," gabions, etc., it would seem to be simply necessary to provide a weapon which could be handled with facility and capable of discharging a sufficiently heavy leaden projectile with accuracy to the required distance; but to pierce the heavy steel and iron plates used in similar siege operations was a more difficult problem, and this has been solved in a most ingenious and effective way. The projectile proper is a hardened steel cylinder, something less in diameter than the bore of the gun, with one end given that rounded form generally denominated conical when applied to a projectile. This cylinder is, to quote their own term, "circumfused" with lead upon its whole length, except a small part of the point, with the usual ring-like projections for filling the rifle grooves of the gun in the use of this projectile against metallic plates, the steel bolt passes through the plate, leaving the coating of lead behind, while the latter serves perfectly to fill the grooves of the rifle and insure that rotation which is required for accurate shooting. The weapon itself is simply a rifle, having the general form of an infantry arm, but of such calibre and weight as to preclude its use as such. It is intended to be used only in the embrasures or upon the parapets of fortifications, and is laid upon some comparatively solid rest, with a bag of sand supporting it at about the centre or just in front of the recoil-hook. The object of this hook and sand-bag is to receive the principal recoil, while in the butt of the stock is a spring, which, reacting against the movable shoulder piece, relieves the shooter from what residual shock there may be. Resting in this way on the sand-bag, although quite heavy, the most accurate aim may be had with it, while, as it has a very simple and quickly-operated breech-loading arrangement, a most rapid and effective fire can be maintained from it. In loading, the breech-piece is thrown to the left, which ejects the empty metallic case; the new cartridge is then inserted, and the breech-piece thrown again to the right, when cocking and discharging complete the round. A man can do accurate shooting with it at a rapid rate; but as this is not important where the gun is used, no trials for rapidity have been had. The calibre first tried was $\frac{1}{2}\frac{1}{0}$ in., but finally reduced to $\frac{4}{7}\frac{3}{0}$ in., which is now the standard bore.

The grooves are eight in number, make one turn in 33.69 ins., are 0.015 in. deep and 0.21 in. wide. The outside diameter of bullet is $\frac{4}{7}\frac{3}{0}$ in. The steel cylinder or "slug" weighs $3\frac{1}{2}$ oz., the charge of powder $\frac{8}{7}\frac{8}{0}$ oz., and the entire cartridge $6\frac{1}{2}$ oz. The weight of the arm, including the recoil hook, is 45 lbs. avoir.; it can, therefore, be easily transported from place to place by one man.

The length of barrel is, including the cartridge-chamber, 37.75 in., and under trial the initial velocity of the bullet was found to be 1408.2 feet per second. The experiments had with the perfected gun were very satisfactory; in one case a $\frac{1}{4}$-inch iron plate backed with $2\frac{1}{2}$ inches of hard wood was perforated at 2000 yards.

At 1500 yards, bags of sand 2 feet in circumference and 3 feet long were placed side by side and penetrated through the whole. Among the later trials for accuracy at a target of 1 foot square: at 600 yards, of 40 shots 7 entered the target; and at 1500 yards, of 80 shots 5 were within the 1 square foot; in fact, such were the results of the entire set of experiments that the Artillery Committee reported that for the purpose designed the gun was perfect, both as to its performance and the facility with which it could be manipulated; and their approval was equally decided as to the simplicity of design and its ability to withstand wear and tear; in their own words, they consider the gun "good and simple in all parts and mechanically perfect."

The cartridge-case is of sheet brass, and is made from a flat piece by means of a longitudinal seam folded after the manner of our ordinary tinners' seam, stamped together; the closed end of the case is in form of a cap stamped up from the sheet and pressed on with a single seam similar to the longitudinal one; this cap is perforated with several holes within a circle of about $\frac{1}{2}$ inch diameter at the centre, for the entrance of the fire. The holes occupy the base of a conical "anvil," formed in the cap, upon which the percussion-pin reacts to explode the percussion-cap which covers the perforations above mentioned.

I will endeavor to give you in future letters, descriptions of the other most prominent articles in this interesting exhibit.

J. T. H.

THE NORWALK PUMP.

OUR illustration represents a steam-pump exhibited at work in the pump annex in Machinery Hall, at the Centennial Exhibition, by the Norwalk Iron Works Company, of South Norwalk, Ct. An excellent feature of this pump is the facility with which the parts can be removed when necessary for repairs. The valve-chest is removable from the steam-cylinder. The inside steam-cylinder, inside water cylinder cover, and the frame-piece between the two are cast in one piece. The piston-rod is of solid cold-drawn composition, and is fitted to the piston-heads by a taper and two check-nuts. The pumping-barrel is a composition tube bearing loosely upon its ends upon collars turned in the main casting, which serves as guides to hold it central, and is held securely in position by the piston-rod stuffing-box screwing into one end, and drawing the tube or bushing against a shoulder at the other end, thus making it perfectly tight and solid. This forms the pumping-cylinder, and all the wear takes place in this bushing. When it becomes excessively worn, it is but a few minutes' work to unscrew the stuffing-box, which is of composition, and can not therefore rust in the thread, to take out the bushing and replace it with another. The old bushing can, however, be restored and replaced if there is time to perform the operation. The collars in the pump and on the bushing are accurately fitted to gauges. No pipe connections need to be disturbed, and hence no delay is experienced.

The pipe connections are made by flanges and stud-bolts, so as to facilitate their removal in case of necessity, by avoiding the annoyance due to corroded screw-threads. The water-valves are placed above the pump-barrel, which is the most favorable position for giving to the pump a free supply of water; they are circular valves, four in number, and are pressed to their seats by spiral springs. The valve-seats are of gun-metal and are turned taper, and driven into the pump, so that they can be readily removed when necessary. The water-valve chest and water-passages being large, a large body of supply water is kept close to the pump-barrel, thus materially assisting the obtainance of a full supply of water to the pump-barrel, an object of great importance when we come to consider the great difference between the displacement of ordinary pumps and the quantity of water actually delivered, especially when running at high speeds. The pump here illustrated is a No. 11, the diameter of the steam-cylinder being 16 inches; diameter of water-cylinder, 10 inches; length of stroke, 16 inches; capacity per double stroke, 10.86 gallons; strokes per minute from 100 to 200; mean capacity per minute, 500 gallons; size of nozzle for fire purposes, $1\frac{1}{4}$ inch; vertical height of stream, 135 feet; horizontal distance of stream thrown, 209 feet; steam-pipe, 2 inches diameter; exhaust-pipe, $2\frac{1}{2}$ inch diameter; suction-pipe of pump, 8 inches diameter; discharge-pipe, 6 inches diameter.

From these figures we find that the water, when the pump is working at its mean speed, travels up the suction-pipe at a speed of about 175 feet per minute only, which is a great advantage, because the column of water is not liable to break in consequence of the friction due to drawing it through the pipe at a high speed—the limit allowed by Mr. Bourne, in his catechism of the steam-engine, being 500 feet per minute, which is allowed to be the fastest speed at which water can be drawn through a pipe in a solid body. It is considered a good pump that will throw 80 per cent of the water due to the displacement of its water-piston; here then is a loss of 20 per cent, which can only be accounted for in the lift and fall of the suction-valves, and in the loss due to the retardation of the water in the suction-pipe, in consequence of its friction against the sides of the pipe. When the water-piston is at the end of its stroke, and its return movement takes place, the piston travels some little distance before the suction-valves close, and during this interval the column of water in the suction-pipe is given a backward motion by the water passing, until the suction-valves close back through those valves. For these reasons it is highly advantageous to make the suction-valves of larger diameter, so that not much lift will be required of them in order to obtain sufficient area for the water to pass through, for the larger the valve the less it requires to lift, and the sooner it closes after the water-piston has arrived at the end of its stroke. Then again we must consider that since the area of a circle increases as the square of its diameter, there is only one fourth as much friction of the water travelling through an 8-inch pipe as there would be if the same quantity travelled through a 4-inch pipe, because the area of contact between the water and the sides of the pipe is as compared to its volume as four is to one. This is supposing the water to travel in both cases at the same speed; but if we require, as in this instance, to draw a certain quantity of water through a pipe in a given time, we must remember that the water will require to pass through a 4-inch pipe at four times the speed that it would require to pass through an 8-inch one, thus again increasing the friction fourfold in the case of the smallest pipe, so that the friction will be only one sixteenth as much in the 8 inch as it would be in the 4-inch pipe. From these considerations the large area of the valves and suction pipes of the Norwalk pump are excellent features. The workmanship upon these pumps is well fitted and finished, and they have a neat and mechanical appearance.

J. R.

LAKE FREIGHTS have never been as low as they are at present, three and a half cents being the prevailing rate on grain from Chicago. On coal to Chicago from this port, the rates have dropped to 40c.; to Milwaukee, 35c.; and to Detroit, 30c. Coal has been very scarce, but the termination of the Tuscarawas Valley troubles will bring an almost immediate improvement in this respect.—*Cleveland Review.*

THE GAUGING OF RIVERS.

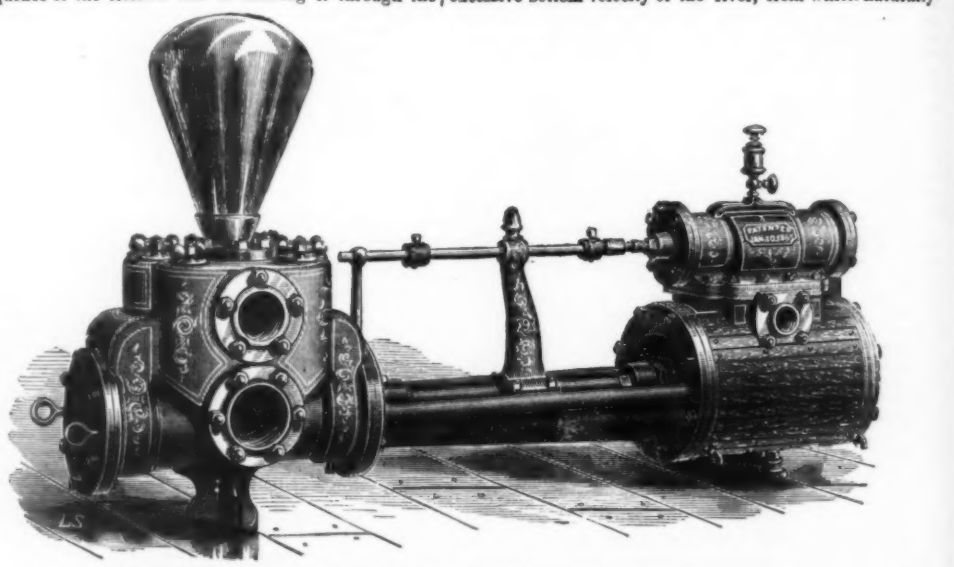
By D. FARRAND HENRY, M. Soc. C. E., Chief Engineer Detroit Water-Works.

IN the year 1850, Congress made an appropriation for the survey of the delta of the Mississippi, and for an examination into the causes of the inundations of that river. In 1851 two parties were formed for the carrying out of this work—one in charge of Capt. A. A. Humphreys, Top. Eng., and the other under Mr. Charles Ellet, Jr., C.E. During the prosecution of the work, Captain Humphreys was taken sick, and the year following a report was made to Congress containing a brief account of his work by Colonel Long, and an extended essay on the causes of the inundations and best methods of preventing them, by Mr. Ellet. The latter used the double float in the determination of current velocities.

In 1857, Congress made a further appropriation for the continuation of the survey, and the work was carried on during 1858 and 1859 by Lieutenant H. L. Abbot, under the general supervision of Captain Humphreys, the methods introduced by Mr. Ellet being generally adopted. The use of the double float was especially continued, metres being reported unpractical and unreliable. In 1861, Captain Humphreys and Lieutenant Abbot made a report to Congress on the "Physics and Hydraulics of the Mississippi," giving an account of the inundations, their causes, and possible prevention, which was simply an elaboration of the previous report by Mr. Ellet, and also a statement of new theories and formulæ for flowing water founded on their velocity observations.

The first error into which they were led by following Mr. Ellet's report was that, contrary to the well-known habit of all other rivers, the bed of the Mississippi was stationary, or, as General Humphreys succinctly expresses it in a letter to the Mobile *Register*, dated June 17th, 1871: "The evidence as to that matter is conclusive, that it has not risen, is not rising, and will not rise." This led them to endorse the levee system, or the raising of the present sinuous banks, and lessening the discharge by means of side channels, an ancient and therefore respectable method, but which has done more to devastate the plantations on the lower river than any other cause. The falsity of this system has been thoroughly demonstrated by many able writers, especially by Mr. Albert Stein, of Mobile, and recently by Captain James B. Eads. Another theory advanced by them, and which was apparently proved by the errors of their current measurements, was the excessive bottom velocity of the river, from which naturally followed the idea that the bars at the mouth of the Mississippi were formed by the material being pushed along the bottom, instead of being held in suspension by the velocity of the current, and dropped when that velocity is lessened by the waters of the river being spread out over the surface of the Gulf. The adoption of this theory also shows the conservatism of the Corps of Engineers, who rejected the jetty system proposed by Mr. Albert Stein in 1835, and in 1838 commenced the dredging and scratching of the bar, because, as Mr. Stein says, "it had been stated by one, unfortunately higher in office than in the science of hydraulic engineering, that dredging has the advantage over all other plans that if it does no good it will do no harm." And so for nearly forty years, at a great expense to the Government, this harmless but useless attempt to abrogate one of nature's laws has been going on; but now, in opposition to the recommendation of the Corps, the jetty system has been adopted, and Captain Eads is proving the falsity of the theory on a grand scale. But the thing upon which the authors of the above-mentioned work most prided themselves was the *discovery* of the parabolic form of the velocity curve, and the elaborate new formulæ of flowing water founded thereon. J. J. Révy, in *Hydraulics of Great Rivers* (page 8), says in regard to these observations: "We have already devoted more space to consider the movement of single and double floats than they deserve at the hands of engineers, and we have done so because one of the largest of any river surveys of modern times—the great Mississippi survey—had been conducted by single and double float observations upon a grand scale as a means to determine the currents of the river. The engineers of that survey relied entirely on floats; and we consider it a misfortune to science and to practical engineering that so much ability, perseverance, and time should have been spent to obtain results which the unfortunate choice of floats has inconveniently marred and confused."

In 1867, General W. F. Raynolds, then Superintendent of the Lake Survey, was ordered to make observations on the outflow of the lakes, and the writer was placed in charge of the work. The first season the double float was used in the determination of the velocities, but with such discordant results that a more careful examination of the Mississippi observations was made to see how the velocity curves then given were obtained. The results of this examination have already been published (*Journal Franklin Institute*, Vol. LXII., and *Flow of Water in Rivers and Canals*, p. 68), but they may be briefly stated as follows: The length of time spent in making the observations shows that at least 10,000 floats were passed at all depths, but on pages 230 and 246 of



THE INTERNATIONAL EXHIBITION OF 1876.—THE NORWALK PUMP.

the report (*Physics and Hydraulics of the Mississippi*), the record of only 2275 of them are given on 69 verticals.

Of these selected observations, Dr. Hagen says (*Bewegung des Wassers in Strömen*, p. 6):

"Extraordinary anomalies are shown when these series are graphically represented. In some of them the curves are quite regular, but in others the velocity remains nearly the same from the surface to the bottom; but frequently, with increasing depth, it increases and decreases considerably. Generally the velocity decreases with the depth, but a few series have an opposite tendency—that is, a surprising increase near the bottom of the river." Of the 69 selected verticals, 24, over one third, show the maximum velocity at mid-depth or below; one of them giving it at one foot below the bottom. This is entirely different from all previous river observations, quite a complete list of which is given in the Report, pp. 204–6, the maximum having been found at or near the surface by all observers. There must, therefore, have been some strong reason for selecting observations which most observers would have rejected entirely.

On page 251 are given some current measurements made on a small canal near Washington, by Lieut. Abbot, in December, 1859. It was found that a reversed parabola with its axis (the maximum velocity), about two tenths the depth below the surface, would pass through most of the observed velocities. This canal was 23 feet wide and 7 feet deep; and according to MM. Darcy and Bazin's experiments on small canals, the locus of maximum velocity should be at a little over two tenths the depth, for a compilation of their observations shows that the maximum on the centre vertical remains at the surface until the depth is about one fourth the width. (*Flow of Water in Rivers and Canals*, p. 19.) In order to make the Mississippi observations agree with the above, the 69 verticals had to be selected and so grouped that the means would give the same result. Besides, this reversed parabola below mid depth is practically a straight line, and cuts the bottom at a very obtuse angle, giving an excessive bottom velocity, which, as we have already seen, they assume to be the fact; although Captain Boileau, from whom they borrowed their parabola, says (*Measure des Eaux Courantes*, p. 302): "The observations should be continued to a short distance from the bottom, for in that region the velocities decrease rapidly." Dubuat found (*Principes Hydrauliques*, p. 100) that the velocity of translation of grains of sand in a small canal was only about three thousandths of an inch per second, where the lowest velocity measured by spheres ¼ inch in diameter was one foot per second. Most European observations confirm the above, but if the "new theories" are correct, the bottom of the Mississippi must be formed of adamant, unless the friction usually found there is absorbed at the surface in the work of lowering the maximum velocity to three tenths the depth. Although none of the observations on the rivers connecting the Great Lakes were as bad as some of the 69 selected verticals, yet as the use of the double float had led to such improbable results, and as in the mean time the telegraphic metre was invented, the latter was used exclusively in the continuance of the work. A series of comparisons was made between the floats and metre at different depths, where the surface velocity was nearly four feet per second, and the depth of the river about 50 feet. At the surface, and for ten feet below, there was but little difference in the velocity given by either, but at 45 feet the floats ran six tenths of a foot per second faster than the velocity shown by the metre, the action of the current on the connecting cord apparently raising the lower float, and thus showing too great a velocity. Afterward, Prof. S. W. Robinson mathematically demonstrated the position of the lower float at different depths, showing that it mainly depended upon the length and size of the connecting cord (*Flow of Water in Rivers and Canals*, p. 75; and Van Nostrand's *Engineering Magazine*, vol. xiii, p. 99). It was also found that the ellipse with the minor axis a little below the surface, used by M. Raconet in the reduction of his observations on the Neva (the only European observations on a deep river), would best agree with the observed change in velocities from the surface to the bottom. These results, unwisely perhaps, were published in General Raynolds' reports of 1868 and 1869, and the General was as soon as possible removed from the charge of the Lake Survey.

A month after his removal, General Humphreys, Chief of Engineers, ordered General Abbot to review them, and the first intimation that General Raynolds had of the dire offence he had committed was the publication of these reviews, and when he forwarded a reply to the Department it was returned, and he was informed that one officer could not review the work of another without being called upon to do so by the proper authority. A copy of the reviews was, however, furnished his successor, and the investigations and work on a final report immediately stopped.

And now in the report of the Chief of Engineers for 1875 is a record of a series of current observations on the Connecticut River, made by General Theo. G. Ellis, under the direction of General G. R. Warren, Corps of Engineers, which are such a remarkable confirmation of the correctness of the form of the velocity curve deduced from the metre observations above noted, that it seems as if they should be more widely known than they can be in that report, where the few grains of wheat are so unexpected and so seldom searched for.

TABLE I.—MEANS OF VELOCITY OBSERVATIONS ON THE CONNECTICUT TAKEN AT TENTHS OF DEPTH.

Tenths of Depth.	Means of all Float Observations. Feet per sec.	Means of all Metre Observations. Feet per sec.	Means of all Observations. Feet per sec.
Surface.	2.38	2.05	2.10
1	2.38	2.12	2.17
2	2.35	2.15	2.19
3	2.35	2.13	2.17
4	2.30	2.08	2.12
5	2.23	2.01	2.05
6	2.15	1.93	1.97
7	2.04	1.81	1.85
8	1.90	1.67	1.71
9	1.66	1.47	1.50
Bottom.	1.18	0.96	1.00
Mean.	2.084	1.853	1.894
Mean of Parabola.	2.114	1.887	1.928

They were mostly obtained by the use of metres, the telegraphic metre being preferred, though a few of the measurements were made with the double float. The final results are given in Table I., copied from a table in General Ellis's report (p. 344). These means were obtained by plotting the observations on a large scale, drawing a free-hand curve through as many of the points as possible, dividing the distance between surface and bottom by horizontal lines drawn at tenths of depth, and noting the points of intersection with the curve.

This method of interpolation was the same as that used by Humphreys and Abbot, and though it can never give a true mean of the velocities, and if the person drawing the free-hand curve has a preconceived idea of the form it ought to assume may be very inaccurate, yet where there are so few missing observations, and the whole work is so carefully done as this on the Connecticut appears to be, the error may not exceed the errors of observation.

The first glance at these means shows a curious anomaly, the float observations giving the maximum velocity at the surface, while the metre shows it two tenths of the depth below.

Now, as we have seen, if floats can be relied on at all, they must be most correct near the surface, and, therefore, there must be some error in the metre measurements. Looking further, we find that in obtaining the coefficient of the metres by drawing them at different velocities through still water, General Ellis so feared the "pushing effect" of the boat that he suspended them five feet in front of it; while when making current measurements from the stern of an anchored boat, he entirely disregarded its retarding influence on the water passing under it, and neglected the writer's advice to hang the metre out from one side of the boat, when attempting to observe in the upper five feet of the stream. Again, the recorded observations show a more rapid decrease of velocity near the bottom than is given in the means. But as there are too few observations at any one depth to eliminate the errors, to find the true form of the top and bottom of the curve, the mean of all the float observations for the upper five feet, and of the metre observations for the lower five feet must be taken. These means are given in the following tables:

TABLE II.—MEANS OF ALL FLOAT OBSERVATIONS FOR FIVE FEET BELOW SURFACE.

Depth.	Velocity. Feet per sec.
0.35 feet below surface	2.47
1.0 " " "	2.47
2.0 " " "	2.46
3.0 " " "	2.42
4.0 " " "	2.42
5.0 " " "	2.38

TABLE III.—MEANS OF ALL METRE OBSERVATIONS FOR FIVE FEET ABOVE BOTTOM.

Depth.	Velocity. Feet per sec.
5.0 feet above bottom	1.94
4.0 " " "	1.88
3.0 " " "	1.78
2.0 " " "	1.63
1.0 " " "	1.41
0.4 " " "	1.20

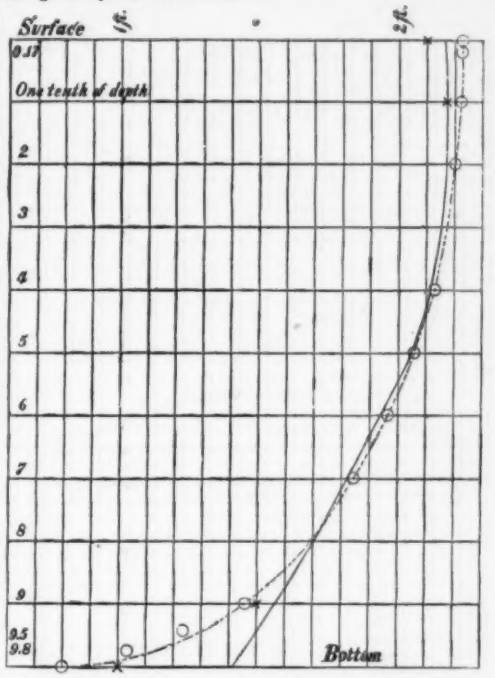
In the following table, the means given in the last column of Table I. are thus corrected near the surface and bottom; the remainder being assumed to be correct, as they can differ but little from a straight line.

TABLE IV.—CORRECTED MEANS COMPARED WITH VELOCITY CURVES.

Tenths of Depth.	Corrected means of all observations. Feet per sec.	Ordinates of Racourt's Ellipse.	Difference from observations.	Ordinates of H. & A. parabola.	Difference from observations.
Surface.	2.23	2.23	0	2.16	—0.07
0.17	2.23	2.23	0	2.16	—0.07
1	2.22	2.22	0	2.17	—0.05
2	2.19	2.20	+0.01	2.16	—0.03
3	2.17	2.17	0	2.15	—0.02
4	2.12	2.12	0	2.11	—0.01
5	2.05	2.06	+0.01	2.05	0
6	1.97	1.97	0	1.95	—0.02
7	1.85	1.85	0	1.83	—0.02
8	1.71	1.69	—0.02	1.70	—0.01
9	1.46	1.46	0	1.56	+0.10
9.5	1.24	1.30	+0.06	1.50	+0.26
9.8	1.03	1.14	+0.11	1.45	+0.42
Bottom.	0.80	0.87	+0.07	1.42	+0.62

In the third column of this table the ordinates of an ellipse are given, calculated by the equation of an ellipse referred to the vertex of its major axis: $X = \frac{B}{A}(2\ Ay - y^2)^{\frac{1}{2}} + C$; in which A = 9.75, B = 1.36, and C = 0.87. This differs but very little from the corrected means except near the bottom, where the velocity is slower than is shown by the ellipse. Probably were the actual bottom velocity known, it would be still less than that given, and doubtless no simple curve can ever be found to correctly express the decrease in velocity near the bottom. In the fifth column, the ordinates of a Humphreys and Abbot parabola are given. From mid depth down this is nearly a straight line, cutting the bottom at an obtuse angle. At the surface it differs considerably from the means, agreeing passably well with them in the centre, but near the bottom it is shown to be the worst imaginable form of curve to express the decrease in that region. In his report accompanying those observations, General Warren says (p. 301): "One of the most important conclusions reached by this is, that both floats and metres give concordant results, showing that each is reliable when carefully and intelligently employed." The floats used in the determination of the outflow of the Lakes were connected by a cord one twelfth of an inch in diameter, and at a depth of 20 feet they gave a velocity less than two tenths of a foot per second greater than the metre; while in these Connecticut observations, where the depth did not exceed 23 feet, a cord only 0.036 inch could be used, and the difference should be proportionately less, as the observations show.

But on the Mississippi, where the depth was often over 100 feet, a rope a quarter of an inch in diameter, or seven times the size of the latter, was considered necessary, and the errors must have been proportionately greater. Possibly, however, the floats were not "intelligently employed" there. General Warren's next conclusion shows how a perfectly fair man may be misled by specious arguments in an intentionally false report, unless he examines for himself the data upon which it is based. "Another most important conclusion from these results (at least to those who have felt doubts) is the full confirmation they afford to the parabolic form of the curve of subsurface velocities as shown in the Physics and Hydraulics of the Mississippi by Humphreys and Abbot. . . . An attentive perusal and examination of General Ellis's report will be necessary to enable one to do justice to this subject. I will not therefore attempt an abstract of it, but will give here but one diagram, showing how well the results of his observations conform to the curve of the parabola given by Humphreys and Abbot's formula. The diagram is No. 9 of Ellis's report." The ordinates of the parabola given in Table IV. are taken from this diagram. It is also shown by the full line in the figure, the circumscribed dots being the corrected means, the crosses near the surface and bottom the uncorrected means from Table I., the curve of the ellipse being also given by the broken line.



The arithmetical sum of the differences between the corrected means and the parabola at the tenths of depth is 0.95, and between them and the ellipse at the same points only 0.13, or less than one seventh the former. The next paragraph to the one above quoted shows how completely General Warren was deceived by the apparent honesty of the report, and how little he examined the details. "The maximum discrepancy is only seven hundredths of a foot per second." A simple inspection of the diagram given would have shown him that the bottom velocity, as plotted, was over forty hundredths of a foot per second from the point where the curve cuts the bottom.

And did General Ellis receive his reward? Yes; in an addenda to the report, General Humphreys says: "The most accurate observations made since [the Mississippi survey] in this country, on a river the character of which admitted of the most refined mechanisms being used—that is, the observations made by General Ellis's party on the Connecticut River—confirm the laws deduced from the Mississippi observations." Unfortunately the observations on the outflow of the lakes did not "confirm the laws," etc., and General Abbot, in his review of General Raynolds' reports, says (Report of Chief of Engineers, 1870): "Let us now consider Assistant Henry's metre. Never having seen the instrument used, I can not form an opinion respecting its relative merit compared with the older types, but from his description it appears to be equal, if not superior, to the best of them. He has certainly obtained by its aid some interesting and novel data respecting pulsations in flowing water. . . . . In my opinion, founded on a somewhat close study of the subject, instruments of this class are pretty toys, which have contributed more to retard the progress of discovery in the science of river hydraulics than any other cause. This is due to the fact that they register their results in a kind of cypher to which we can by no means be sure that we possess the key. . . . . That by its use in a proper manner a tolerably correct idea of the discharge of a river may be obtained, is not improbable; but that by its aid it is possible to determine in a scientific manner so delicate a change in the velocity as that existing between the surface and the bottom, is doubted. The errors of the double float may be cancelled by multiplying the observations, but errors in the coefficient of the metre always act in the same direction under similar circumstances, and can not, therefore, thus be annulled."

How easily the "key" to this "pretty toy" is found and its "errors annulled," when a person is discovered who will report that his observations "confirm the laws," etc. It has been assumed throughout this paper that the telegraphic metre used in the Connecticut was the same as that previously described in General Raynolds' report, and in fact the plates accompanying General Ellis's report are almost an exact copy of those published in the *Journal of the Franklin Institute*, and as a frontispiece to flow of water in rivers and canals, even to the method of observing; but the only thing General Ellis says about it is: "The second current metre used was one constructed especially to avoid some of the difficulties usually encountered with such instruments. . . . . In order to have as little friction as possible, the apparatus was made to record by breaks in an electric current." It is fortunate that the metre was used by one who could bring himself to make such a report that his observations would be allowed to be so fully published, otherwise this remarkable confirmation of the correctness of Racourt's ellipse in expressing the vertical velocity curve might have been utterly lost to science. Let all who are engaged on such work in the future, from this shining example, "learn to bend the pliant hinges of the knee, that thrift may follow fawning."

But may we not be entirely mistaken in General Humphreys' position in this matter?

His addenda to the report of General Ellis, which is apparently an answer to the objections to the use of the double float, would seem to confirm this view; for it is so weak that it could never have been seriously written.

The only point made in it is that as the rod on the upper float was always vertical, the connecting cord could not have had any dragging effect upon it, as in that case it should have inclined down stream.

Now if he really believes that the maximum velocity is three tenths of the depth below the surface, would he not have said that the effect of the cord would have been to incline the rod up stream? If this is the true cause of the publication of these observations, let us honor him for facing toward the right, and hope that some day he may be enabled to fully acknowledge his errors.

SURFACE-CONDENSER FOR STEAM STREET-CARS.

By W. R. ROWAN, Randers, Denmark.

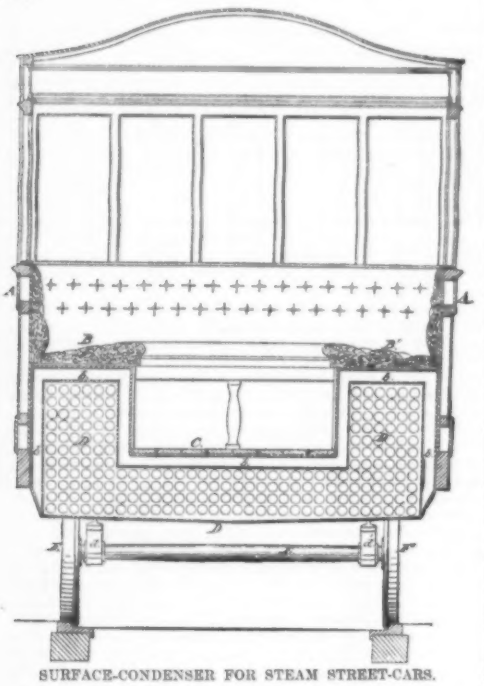
THIS invention consists of a surface-condenser that fits under the car-seats or other unoccupied space about the car, and is connected by a narrower part running under the floor, and thus connecting the two parts under the car-seats.

To facilitate the condensation of the exhaust steam from the engine, a fan or blower is employed, of any ordinary construction, to pass or force a rapid current of air through the tubes, and thus cool them.

The drawing represents a vertical section of a car with the condenser in position. A represents a car provided with seats B and suitable floor C. Under said seats and floor is arranged the surface-condenser D, and filling up, as nearly as possible, the entire space under said seats. To the bottom of the condenser may be attached the pillow-blocks or bearings *d d* for the axle E and wheels F F, it forming part of the car-body, if desirable.

A space, *b*, may be left around the sides of the condenser, and either filled in with non-conducting material, or it may be an air-space for the circulation of air.

The condenser may form the seats, sides thereof, and the floor, and may be made of iron in one piece, or riveted together out of sheets, and secured to the car itself in any suitable manner, forming, in fact, the lower part of the car-body.



SURFACE-CONDENSER FOR STEAM STREET-CARS.

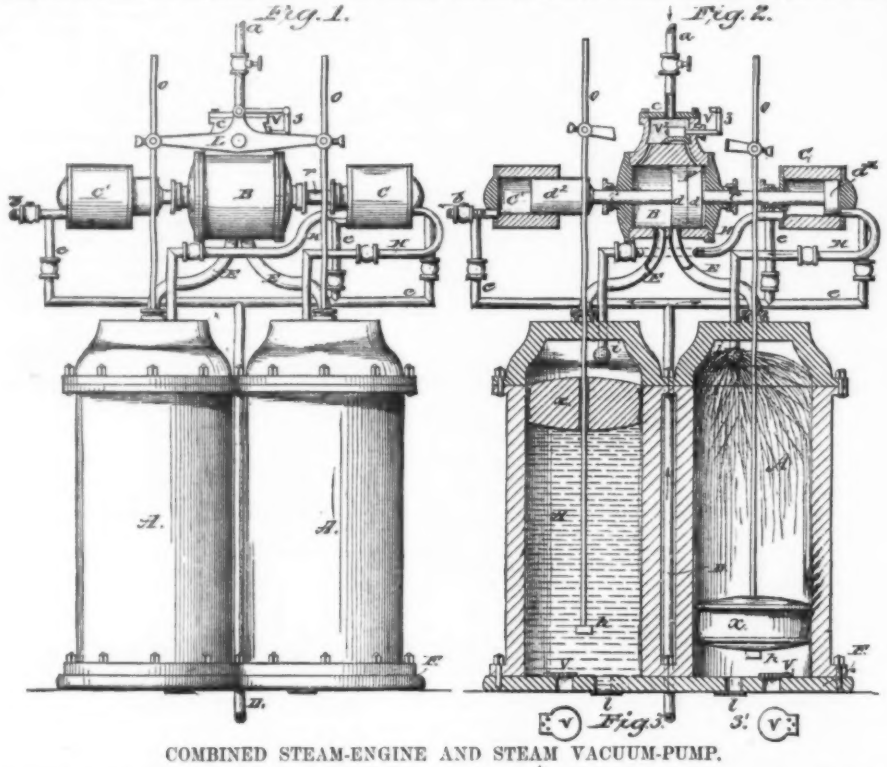
The great advantages of this condenser will be readily appreciated by those familiar with the art, and they are: large condensing surface arranged in a very small and compact space; the condenser is out of the way, and may form part of the car-body itself; the space hitherto unoccupied in street and similar cars is made use of to condense the exhaust steam, by which horses are frightened when it is allowed to escape into the atmosphere, besides causing sparks to be thrown into the air and streets, or to cause conflagrations of combustible material; the condenser is very simple, and may be constructed in any suitable manner and of any suitable material, to occupy substantially the space shown and described.

COMBINED STEAM-ENGINE AND STEAM VACUUM-PUMP.

By GEORGE R. GLEASON, Beloit, Wis.

FIGURE 1, side elevation; Fig. 2, vertical section; Figs. 3, 3′ common clack-valves; Fig. 4 is a top or vertical view of the parts indicated by the letters C′, B, and C, including the cylinder-heads of the pump, as shown at Fig. 1; A A, cylinders of the pump; F F F, the bottom plates of the pump-cylinders; V V are induction-valves, and *l l* are valves leading to the eduction-pipes; D is a pipe for supplying water to the injecting-pump C and the boiler feeding-pump C′ through the pipes *e e*, with which the pipe D connects, as shown, in the direction shown by the arrows. B is a steam-cylinder, supplied with steam by the pipe *a* through the steam-chest *c*, from which steam is admitted to the chambers or main cylinders A A through the pipes E E. L is a walking-beam, connected with the floats *x x* by means of the adjustable rods *o o*, stop-collars *h h*, and which floats, by means of said rods and walking-beam, operate the cut-off valve V^2 by means of the valve-stem and arm V^3. C is a double-acting pump, for injecting water into the cylinders A A through pipes H H. C′ is a single-acting pump, for feeding the steam-boiler through pipe *b*. *r r* is a piston stem or rod, provided centrally with a piston-head P, having expansion packing-rings *d d*, as shown, and at either end having a water-piston head, d^2 d^2, all as shown. *i i* are perforated hollow globes, connected to the lower ends of the pipes H H, for the purpose of breaking the water into spray when being forced into the cylinders A A.

The cylinders, and all other parts for which cast-iron is available, are made of that metal. The piston-rod *r r* is of steel, the rods *o o* of brass or other suitable metal, and the floats *x x* are made of sheet-copper or other available material, all manufactured and finished in the usual style of the machinist's art. The pump is started or put into working operation by first turning on steam through the pipe *a*, admitting it to the steam-chest *c*. The cut-off valve V^2 is then set in motion by means of hand manipulation of the walking-beam L, thus operating the valve V^2 by means of the arm and valve-stem V^3, alternately admitting to and cutting off steam from the right and left-hand ports to the steam-cylinder B, as shown, and when steam is thus admitted to said cylinder the piston-rod *r r*, upon which is rigidly fixed the piston-head P, provided with expansion packing-rings, as shown, is caused to reciprocate to the right and left by regular alternate strokes, as shown, and which will be readily understood. The piston-rod *r r* also has a suitable head or plunger rigidly attached at each end, marked d^3 d^3, and it will be seen that when set in motion, as hereinafter described, the piston-heads P and d^3 d^3 all co-act and discharge their respective proper functions at the same time, causing the pumps C and C′ each to draw water through the pipe D and branch pipes *e e*. A suitable and regular supply of water is then, with concentrated force, injected by the pump C, through pipes H H and perforated globes *i i*, into each of the cylinders A A alternately. The pump C′, at the same time, forces a regular and sufficient supply of water into the steam-boiler through the pipe *b*. When the pump has thus been set in motion by hand-power, as before described, a supply of steam being in readiness for working the whole mechanism of the device, steam is admitted through the pipes E E into the cylinders A A, regularly alternating with the injection of water into said cylinders, as hereinbefore described. The alternating supply of steam through pipes E E is regulated by the lateral action of the piston-head P, thus discharging the function of a valve. The action of the piston-head P (acting as a valve) and the strokes of the pump C produce exactly equal alternating admissions of steam and injections of water into each of



COMBINED STEAM-ENGINE AND STEAM VACUUM-PUMP.

the cylinders A A, and as soon as the steam and water thus admitted and forced into either of the cylinders A A, as before described, come into contact with each other, a vacuum is instantly formed, at once causing the cylinder to fill with water forced in by atmospheric pressure from the well or reservoir through the induction pipe V, and the float *x* in the cylinder, thus filled, will be carried upon the surface of the water to the top of the interior of the cylinder; and while one of the cylinders is thus being filled, the water in the opposite cylinder is being expelled therefrom by the force of steam admitted thereto, as aforesaid, through the outlet-port *l*, and when the water in said cylinder shall fall below the stop-collar *h* upon the rod *o*, the weight of the float *x*, acting by its gravity upon said stop-collar *h*, causes the steam to be cut off and reversed to the opposite port of the cylinder B, as shown, and thus causing the operation above described to be repeated.

The rod *o* may be adjusted by means of thumb-screws in the ends of the walking-beam L, so as to check the downward movement of the floats *x x* at any desired point, and by this means the pump may be caused to work at any percentage or degree below its maximum capacity; and this is a feature in my invention of great importance in an economical point of view.

The floats *x x* are made a trifle smaller than the interior diameter of the cylinders A A, for the purpose of preventing downward pressure of steam upon their upper surfaces, also fitting loosely upon the rods to permit them to move freely up and down thereon.

The pump C′ enables me to dispense with the use of a separate pump to supply water to the steam-boiler, as heretofore used in steam vacuum-pumps, thereby saving much expense.

GRINDING AND POLISHING.

By JOSHUA ROSE.

No. 1.

ARTICLES of metal requiring to be polished require to have the surface removed before the polishing can be performed, because the materials used in polishing are too fine and cut too little to reach the fine hollows upon the surface of the articles.

Grinding may be aptly termed the first stage of polishing, because a ground surface has a certain amount of polish to it, and the finer the grinding the greater the polish. Grinding, however, as generally understood, is the operation of removing by abrasion the outer surface sufficiently to remove the forged or cast surface, and thus prepare the work for the polishing process.

The appliances used in grinding are first the grindstone, which is of large diameter for ordinary or flat work and small when the surface of the work requires to be concave, as in the case of razor grinding. The stones are run at a high speed, and kept wet with water. The work is performed with the stone running from the operator. It is of great importance that these stones should run true, because in that case the work can be performed much more rapidly and true. An instance of this occurred some years ago, when a large railroad company desired to have the surfaces of their locomotive guide bars fitted up by the piece. The work, which, together with the fitting of the guide blocks, had been costing about ten dollars per engine, was taken by one of the workmen for $8.40, which price was paid for a period of about a year. During this time there had been made several experiments with a view to grind the bars as true as possible. The method adopted was as follows: The stone upon which the operation was performed was about 4 feet 6 inches in diameter, and ran at about 300 revolutions per minute. The bars were held upon the stone so that the grinding marks ran crosswise of the stone; hence the width of the face of the bars would grind concave unless the bars were given a slight motion. This, however, the grinder so successfully performed, that with a surface plate to test with, he managed to grind the surfaces so true that it took more work to efface the grinding marks than it did to finishing the truing of the surfaces; notwithstanding that the top as well as the bottom bars were made, both on the inside edges as well as on the faces, very true to a surface plate, and it was required that the finishing should be done with a superfine smooth file, and that no scratches should be left in the work. To save the work entailed in filing out the grinding marks, which latter proved very destructive to files, it was first attempted to grind the bars lengthwise on the stone; but this was found impracticable, inasmuch as it was not possible, with the utmost of care, to grind the surfaces flat. The stone was made as true as possible and the experiment repeated, but still the faces of the bars were rounding, entailing a deal of extra work to true them before commencing the draw-filing. The next experiment made was to grind them crosswise of the stone and true to the surface plate, and then draw them lengthwise along the stone, performing just sufficient grinding to alter the direction of the grindstone marks. This, too, proved a failure, because the stone not being quite true—and it is impracticable to keep such a stone true—the bar would jar and tremble upon the stone, and the motion would cause the face of the bar to become rounded. In course of time, however, the machinist left the shop, and estimates for the job were tendered by many others among the workmen. One, however, offered to do them—that is, the eight guide bars and the four guide blocks—for $4\frac{20}{100}$ per engine. This price was considered too low to enable the workman to deliver good work and make day wages, let alone the customary $2 per day, which was allowed for piece-workers. He, however, had the bars ground crosswise of the stone and trued as usual, after which he drew them lengthwise along a stone running *so slowly* that the inequalities of the stone did not cause the bars to jar or tremble in the least; and so no matter if the stone was half an inch out of true, it would not affect the truth of the bar faces. By this simple expedient he saved one half of the work, and earned on the bars and blocks, for over ninety locomotives, an average of $2\frac{39}{100}$ a day, or 30 cents a day more than had been earned when more than double the price was paid. The difference, however, is made more apparent by considering the time taken to perform the work, which was by the first workman an average of about $4\frac{1}{2}$ days per set, and by the second workman in a little over $1\frac{5}{10}$ days. The edges of the bars were rounded to a $\frac{5}{8}$ inch radius and the corners of the guide blocks were filed to fit those of the bars. The shop in which this took place employed at least 100 men upon vise work, and yet none of them perceived the manner in which this saving was effected; so that after the second workman left that shop no one could be found, not even among the apprentices, many of whom had served five or six years at the trade, to take the work at the same price. This circumstance occurred ten years ago, and the simple expedient above described has not, even yet, been discovered.

The method of truing large stones true is by hacking them, which is performed as follows: The stone is run at a speed of about 100 revolutions per minute, while the operator resting his hand upon the grinder's seat or saddle holds a piece of coal or chalk so closely to the stone that it will touch the high spots, and by moving the position of his hand he makes across the face of the stone a series of marks about $\frac{1}{2}$ inch apart, and made upon the high places only.

The distinctness of these marks informs the operator of the amount necessary to take off in order to true the stone. To do this he stops the stone, and taking an implement, such as shown in Fig. 1, strikes the stone as with an axe, crossing the cuts as shown in Fig. 2, in which A represents a grindstone, B, B, B, B, B the circumferential marks made by the piece of coal, and denoting the high spots of the stone, and the diagonal marks on B, B, B, B, B, showing the hacking marks, which are mere indentations. It will be observed that the hacking marks are heavier and closer together at 1, 4, and 5

than at 3 and 2, the latter being the lightest and widest apart. The reason of this is that the truing marks show the heaviest at 1 and 4 and the lightest at 2, and the hacking is therefore performed most at 1 and 4 and least at 2. It will be also observed that the hacking does not altogether remove the high places, but removes a large proportion of the area, so that the places hacked wear away more rapidly than the rest of the surface of the stone. The hacking not only serves to keep the stone true, but it sharpens it so that it will cut more freely; for if the surface of the stone gets smooth it will not cut freely. At times the surface of a stone will get glazed, through being used on soft metal, as the particles of the metal will adhere to the face of the stone; to remedy which the grinder takes a piece of round bar iron, about an inch in diameter, and holding it against the stone with its length standing at a right angle to the cutting face, he forces it against that face with great pressure, resting it against the face of the horse, and forcing it to the stone with a piece of wood hollowed out at the end to form a bearing in which the bar may revolve. The piece of iron should be a foot, at least, longer than the width of the cutting face of the stone, so that one end will be long enough to permit of being guided by the left hand, which must not grip the bar but steady it only, permitting the bar to revolve, as it will do from the friction of the stone. While this operation is being performed, the stone should be kept well supplied with water, and the bar should be given lateral movement across the face of the stone. The pressure with which the bar is held to the stone is by some made intermittent, by which means the action is claimed to be more efficacious. Both brass and cast-iron work dull the stone very quickly.

For purposes in which the work is not required to be of standard sizes, the grindstone is a valuable tool, because it will cut much more rapidly than a file, and where the quantity of metal to be taken off is small, much more rapidly than a planing machine; and since the work requires no setting, it possesses, for such purposes, a very great advantage, in the matter of time, over a planer, because the position of the work can be moved in the hands almost instantaneously; on small work this is highly beneficial. Then the stone being worked with water applied the work does not get hot, and hence difficult to handle, as is the case with using solid emery wheels, so that hardened work, which could neither be filed nor planed, may be ground without becoming softened at all. A skilful grinder will do a great deal of work, and make it

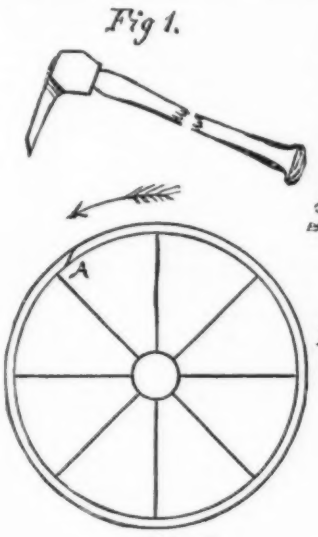


Fig 1.

Fig 2.

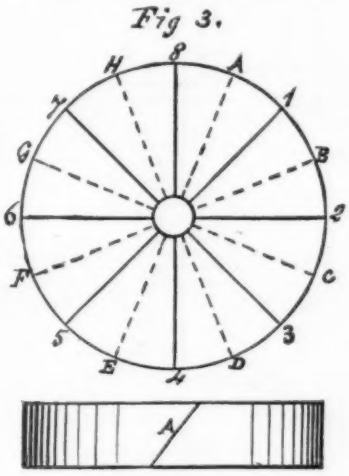


Fig 3.

Fig 4.

Fig 5.

GRINDING AND POLISHING.

true and of ordinary uniformity of size. For large flat surfaces, however, such as the plates used in safe-making, the grindstone can not be so profitably employed, because the operator can not see where the stone is cutting, and has to keep reversing the plate to see how the operation is proceeding; then again, the water from the stone, together with the grindstone grit, diffuses over the surface of the plate, rendering frequent wiping necessary, and a heavy or large plate is an awkward thing to handle, requiring the employment of two or three men, and even then the work can not be performed with much exactitude, because of the grinding being performed out of sight; for such purposes, therefore, a solid emery wheel is the best. It is slung in a wooden frame pivoted upon a shaft hung in bearings, and with provision to give the emery wheel a swinging and horizontal movement, the latter by means of perpendicular adjustment, which operates automatically from a slight vertical pressure. The work lies horizontally with the face to be operated upon upwards, and the emery wheel, which is usually about 2 feet diameter with about a 4 to 6 inch face, revolved at a high speed by suitable belting, is brought into contact with the face of the work and operated over it, the amount of pressure of the wheel to the work being regulated by the hands upon the frame carrying the emery wheel.

POLISHING WHEELS.

Of polishing wheels there are several kinds. First those of wood with a leather face. These are built up of sections of wood fastened together by gluing, and with wooden pegs in place of nails or screws. The joints of the sections or segments are broken—that is to say, suppose in Fig. 3 that 1, 2, 3, etc., up to 8 represent the joints of the 8 sections of wood forming one layer of the wheel, the next 8 sections would have their joints come at the dotted lines A, B, C, etc., up to H. The thickness of these sections is usually made of hard, well-seasoned, soft wood, such as pine, and to prevent them from warping after being made into a wheel it is advisable to cut out the sections somewhere near the size in the rough and allow them to lay a day or two before planing them up and fitting them together, the object being to allow any warping that may take place to do so before the pieces are worked up into the wheel, because if the warping takes place afterwards it will be apt to throw the wheel out of true, whereas it is necessary that these wheels be very true, not only so that they may not prove destructive to their shaft-bearings, but that they may run steady, and not shake or tremble, and because the work can be made much more true and smooth with a true than with an untrue wheel. Only one layer of segments should be put on in one day, and they should be on as quickly as possible after the glue is applied, so that the latter shall not get cold. So soon as each segment is put into its place it should be clamped firmly to its seat and driven firmly up to the joint of the next one, and when the layer is completed it should be left clamped all night to dry. In the morning one clamp should be removed, and that section fastened by boring a small hole and driving therein round and slightly tapered soft-wood pegs of about ¼ inch diameter. The whole of the sections being pegged the next layer of segments may be added, and so on until the required width of wheel is attained. The whole wheel should then be kept two days before it is turned, and as little as possible should be taken off in the turning process. The circumferential surface should be turned slightly rounding across its width, and as smoothly as possible. It is practicable to proceed with the construction of the wheel without nailing between the various operations so long as here advised, but the wheel will in that case be more apt to get in time out of true. To cover the circumference of the wheel sole leather is used, its thickness being about ¼ inch; it should be put on soft and not hardened by hammering at all, and with the flesh side to the wood. The joint of the leather should not be made straight but diagonal with the wheel-face, the leather at the edge of the joint being chamfered off as shown in Fig. 4 at A, and the joint made diagonal, as shown in Fig. 5 at A.

If the leather was put on with a square butt joint there would be apt to be a crease in the joint, and the emery or other polishing material would then strike the work with a blow, as well as presenting a keener cutting edge, which would make marks in the work no matter what pains might be taken to prevent it. This, indeed, is found to occur to a slight extent upon very fine polishing, even when the joint of the leather is made as above; and the means taken to obviate it is to not put any polishing material on the immediate joint and to wipe off any that may get there, leaving $\frac{1}{16}$ of an inch clear of polishing material. It is obvious that in fastening the wheel to its shaft it should be put on so that it will run in the direction of the arrow, providing the operator works with the wheel running from him, as is usually the case with large wheels, that is to say, wheels over 18 inches in diameter. In any event, however, the wheel should be put on so that the action of the work is to smooth the edge of the leather joint down upon the wheel, and not catch against the edge of the joint, which would tend to rough it up and tear it

SOME RECENT RADIOMETRIC EXPERIMENTS IN GERMANY.

SINCE the radiometer was described by Mr. Crookes, it has been the subject of a large amount of observation, both in this country and on the Continent. We propose here to give a short account of two series of experiments lately made with it in Germany, where it generally passes under the name of the "Lichtmühle," or light mill. They appear to give some useful aid towards comprehension of the action of this somewhat enigmatical apparatus. The radiometers used were of the kind constructed by Geissler, of Bonn. They are wheel-shaped, the wings consisting of small leaves, apparently of annealed mica, blackened on one side with lampblack; they are connected by platinum wires with a small cap, which turns on a fine needle point. The mill is enclosed in a vessel of thin glass, in which the air has been rarefied as much as possible. One series of experiments is that by M. Wartmann, described in the *Archives des Sciences* for March; the second by M. Weinhold, in *Carl's Repertorium für Experimental Physics* (Bd. xii., p. 105).

M. Wartmann had two radiometers, the one, A, with square, the other, B, with round wings. If both are exposed to the action of flame, or a glowing metal, or dark heat from an intense source of heat, they rotate with more or less rapidity, and the black surface is repelled. This may be called the "direct" rotation. The same occurs when the rays fall only on the black surfaces of the wings. On the other hand, there is a distinct difference between A and B, when the black surfaces are covered and the others exposed to the sun. While A shows a slow, direct rotation, B shows a distinct reverse rotation. In order to obtain this reverse rotation with A, the sunlight must be concentrated with a lens, and made to fall on the uncovered surfaces, while the blackened surfaces are very carefully protected against any radiation. If a less energetic source be made to act on B—namely, a glowing platinum spiral or a moderator lamp—then, without a lens, the reverse rotation is obtained slow and discontinuous; but it can be obtained easily, if two sources are used, acting in opposite directions on the uncoated surfaces, at the two ends of a diameter. If the source be removed, or its energy diminished, the motion of the mill takes place in a jerking manner. The velocity is greatest if the plane of the wing stands at right angles to the line of shortest distance from the source of radiation, the velocity diminishes with increasing obliquity of the repelled wing, then it becomes greater at the moment that the following wing receives the heat rays at a right angle.

On the two opposite surfaces of the same wing of B are concentrated by similar lenses the rays from two moderator lamps of the same calibre. By changing the distance of the lamps, one may succeed in entirely neutralizing their opposite actions. The action exerted on the black surface is then 11.9 times weaker than that on the white surface, "whence it follows, that to obtain equilibrium the intensity of the pressure must be in inverse ratio of the power of absorption. The least change of the distance, or the energy of the lamps, renews the motion." In a horizontal plane, and concentric with the radiometer, was placed an iron ring which had been raised to a red heat. Forthwith the rotation began, and it became very strong if the plane of the ring coincided with that of the arms. At equal distances above and below from this plane the velocity is the same. The radiometers were placed in a blackened case, which was perforated with an opening above. By means of a mirror a thin bundle of sun rays was reflected vertically and parallel to the plane of the wings. There always occurred a direct motion, whether the light was directed before the white or before the black surface; in the latter case the motion appeared to be quicker. If a moderator lamp be used instead of sunlight, the rays must be concentrated with a lens. The interposition of a very transparent plate of alum weakens to a great degree the action of a good lamp on A and on B. The two radiometers are unresponsive to the largest sparks of a Ruhmkorff coil or a Holz machine, but the wings are distinctly attracted on approximation of an electrified body. In the magnetic field of a large electro-magnet, the mills show the ordinary actions of induction. In water of 12 deg. within a cylindrical glass vessel A behaved as in air, but its rotation was under these conditions slower. The radiometer B, on the other hand, showed the reverse rotation when the rays of a strong moderator lamp were concentrated with a lens on an uncoated wing. If the water in which the instruments are be heated to 60 deg., they remain motionless. When the radiometers are placed over a stream of heat, for example, an alcohol lamp with flue, the rest or motion of the mills is no way affected. When, however, the rising stream of hot air has raised the temperature of A to melting of the shellac on the point of the apparatus, the mill moves a little with frequent intermittence, and at length shows a slow, direct rotation. This suddenly ceases if the source of heat be removed, and it is slowly reversed during the first phases of cooling.

"The difference," M. Wartmann observes, "in behavior of the two radiometers, could not arise from the unequal surface of their wings. It appears to me rather that in the interior of B the rarefaction of air had not been carried so far as in A. Further, the white surfaces of B have a higher polish and brightness than those of A, their power of reflection must therefore be greater. These various experiments appear to confirm the view which attributes the movements of the mills to the expansions of the gaseous bodies under very weak pressures." The experiments made by M. Weinhold had the direct object of testing the different explanations that have been offered of the phenomenon. He, therefore, made a number of changes in the radiometers, some of which we shall notice. He first convinced himself that different specimens of the instrument are sensitive in quite different degrees to radiation of varying strength; and, therefore, that the wheel-shaped radiometer is not directly reliable as a measuring instrument for the strength of the radiation. M. Weinhold obtained radiometers which ran backwards on the radiation being cut off by using transparent mica leaves instead of the annealed and untransparent ones. If such an instrument be exposed a few seconds to strong radiation from a gas flame, and the flame be then removed, the mill first comes to rest and then begins to make a number of rotations in the opposite direction. This backward motion, however, is not due to action of backward radiation through the mica; for on interposition between the four wings of four new unblackened wings, consisting, in one case, of transparent mica, and in the second of annealed mica, the backward motion occurred in both cases. It is more probable that the backward motion is simply a consequence of radiation of the blackened surfaces, but that it only occurs when the wings have sufficient capacity for heat and conducting power. Indeed, radiometers with wings of magnesium metal show the backward motion in a remarkable manner. Some further modifications of the radiometer by inclination of the wings to the horizon, and by alternate use of blackened and unblackened annealed and transparent mica-leaves—for particulars of which we must refer to the original—convinced M. Weinhold that the motion is neither due to currents of minute quantities of gaseous matter, nor to the impellent force of evaporating water. It is rather, he thinks, due to some action—yet to be elucidated by experiment—of rays absorbed by the surfaces, and is in proportion to the amount of this absorption.

MANGANESE BRONZE.

AT the Woolwich gun factories, in England, experiments in the formation of a new alloy composed of copper, zinc, and manganese, are attracting much attention. The new metal is formed by the addition of from 1 to 2 per cent of manganese to the proper proportions of copper and zinc for the making of either bronze or brass. The alloy is said to be stronger than iron, and can be forged, rolled, and readily manipulated at a red heat. It is recommended for the sheathing of vessels instead of copper; and it is said to be better adapted for the armoring of war vessels than either iron or steel, since it is both lighter and less easily penetrated by shot. Its cost is about the same as that of brass. The experiments which have been made in charge of Col. Younghusband, seem also to demonstrate that the new metal will go into use for the construction of guns.

THE ST. GOTHARD TUNNEL.

AT the close of April, the St. Gothard Tunnel had been pierced on the Goeschenen side to the extent of 10,263 feet. The corresponding progress effected at the same date on the Airolo side was 9830 feet. The aggregate distance pierced April 30th, 1876, was thus three miles 4253 feet.

LOCOMOTIVE CONNECTING AND PARALLEL OR COUPLING-RODS.

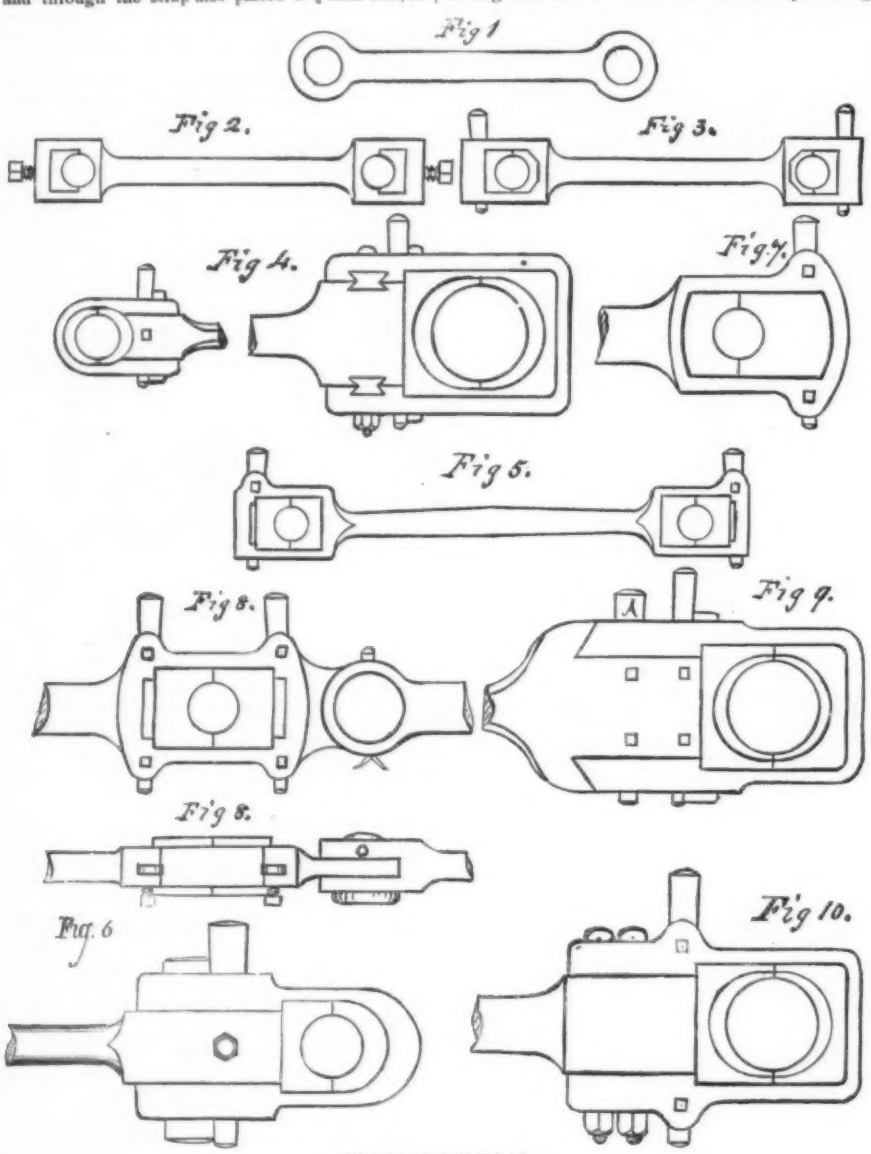
By JOSHUA ROSE.

THE earliest form of connecting-rod of which we have any knowledge, as applied to the locomotive, is that shown in our illustration in Fig. 1, in which there is no means provided to take up the wear of the journals. It was made entirely of wrought iron. It next assumed the form shown in Fig. 2, in which the wear of the journals was taken up by a movable brass and adjusting set-screw. The end of the set-screw, however, bedded into the brass on account of the small area on the end of the screw, so that the brasses were apt to get loose and require too frequent adjustment; and since the wear of the journals gradually shortened the length of the rod, that shown in Fig. 3 was introduced, having back as well as front brasses and keys, instead of set-screws. This rod, as were Nos. 1 and 2, was retained on the journals by a nut and washer. With the introduction by Timothy Hackworth of inside cylinder locomotives, it became necessary to provide some means whereby the brasses could be put upon their places in two halves. Before this, the ends of the journals being projecting pins, or pins which could be taken in and out, the rod entire could be slipped into its place; but the introduction of inside cranks rendered this impracticable, hence Hackworth introduced the connecting-rod strap and the jib and key in the form shown in Fig. 4.

The strap at the large end was secured by two dies, through which and through the strap also passed a ⅞-inch bolt, secured beneath by a nut. The strap at the small end was secured by a jib and key, the crowns of both the small brasses being circular, with a solid feather cast on the centre of the crown, and a featherway cut in the inside crown of the strap and of the rod end. These rods were used on the engines made by Sharp & Roberts and Sharp Brothers. The defects of this rod were that it was very costly to make, the dies were difficult to fit, and soon became loose, permitting the strap to move sideways, so that the flanges of the brasses wore into the strap and the rod end. At the small end the circular shape of the crown of the strap and the rod end made the lining up (which was necessary to preserve the length of the rod, as well as to bring the key up when it had passed through the key-way, so that the key-head was level with the strap, in consequence of the wear of the brasses) a costly job, because the liners had to be filed thin at the edges and of an even sweep to the thick part at the crown, for if the bedding of the liners was not finely adjusted, the strap would spring from the rod end, so that it would not fit properly. Then, again, the feather at the back of the brasses made it necessary to fit the brasses to the strap and small rod end by the hammer, chisel, and file. In repairing these rods, however, this feather was often cut away for ¼ inch inside of the flanges, so that the brasses could be soldered together and the flanges turned to fit the strap. Shortly afterwards, Bury introduced his four-wheel coupled engines, upon which the first coupling-rods appeared. These engines had inside cylinders, with the slide-valves on top and in the smoke-box. The frames of these engines were similar to those now used in the United States. The taper shoes, to take up the wear of the axle-boxes, were used, with screws and nuts for their proper adjustment. The link die was held to the end of the rock shaft by a steel pin fitted taper, and keyed into the rock shaft, and the eccentric rods had hooks instead of double eyes. The coupling-rods used upon these engines, as made by Bury, Curtis & Kennedy, are shown in Fig. 5 of our engraving. The stem of the rod was round and turned in the lathe. The box for the brasses was forged solid, and with a projection on the top to compensate for the metal lost in taking out the key-way, the hole for the set-screw being in the projection. This rod somewhat improved is the one still used for coupling-rods in England, as will be observed by referring to Fig. 7. The crank-pins in these engines had a nut and washer to retain the coupling-rods upon their places. Both the keys are, it will be observed, outside the crank-pins, so that the rod wears shorter.

Of Crampton's engines, the first had 7-feet driving-wheels, placed behind the fire-box, with the cylinders between the two front pairs of wheels. The connecting-rod pin was held in the wheel, and a crank, outside of the rod, carried a pin true with the centre of the driving-wheel, upon which solid double brass eccentrics were attached to work the link motion. The second kind of Crampton's engines had 5 feet 6 inch wheels placed behind the fire-box; the coupling-rods and the connecting-rods were attached to an intermediate shaft, the cylinders being beneath the smoke-box.

The first of these engines had the connecting-rods made at the large end, with straps, jibs, and keys, as shown in Fig. 6, the small ends being forked. But the second class had connecting-rods with the small end after the style of Fig. 6, but with two jibs, one each side of the key, and the large end such as shown in Fig. 10, which class of rod is used in England at the present time for almost all inside-cylinder engines. The coupling-rods shown by Fig. 7 were used on the second class for connecting the crank-pin of the driving-wheel to the crank-pin of the intermediate shaft, and were an improvement on Bury's coupling-rods, inasmuch as that provision was made for two set-screws; and, furthermore, the space occupied by the key brass was made longer, so that the crank-pins, instead of having nuts and washers outside, could have solid flanges These flanges were filed flat on two diametrical sides, so that by placing these flat sides horizontal, and putting in the back brasses into their places in the coupling-rods, the latter would pass over the flange of crank-pins, and after being pushed forward, the key brasses could be put in. In the four-wheel coupled outside-cylinder engines made by Stephenson, there were two motion-bars, one top and bottom of the crosshead, which had a gudgeon to receive the fork ends of the connecting-rods, the forks of which were similar to those used on Crampton's eight-feet driving-wheel engines, of which a brief description may here be given. The rods were forked to clear the hanger which carried the motion-bars; the brasses at the forked end had flanges on each side, and were put in from the open end of the fork. There were raised projections to compensate for the loss of metal due to the keyway, and set-screws on the top only. The keyways passed through the solid brass, and the latter was secured by a jib and key, the jib facing the open end of the fork. Upon the inside-cylinder six-wheel coupled engines, made in about 1843, by Kitson, Thompson & Hewitson, the coupling-rods were made for the leading and trailing wheels as shown by Fig. 7, but the design for the driving-wheel rod ends were as shown in Fig. 8, which is still employed both in England and the United States. The two keys are for the purpose of adjusting the length. The pin shown in the double eye was sometimes secured by the taper-pin, as shown, and at others by a nut and washer, with a split pin passing through the nut. The defects of the rod shown in Fig. 4 led to the construction of the rod shown in Fig. 9, the sole duty of the key A being to lock the strap to the rod end. The keys of these rods were made round on one edge, so that cutting out the key-ways should not weaken the strap. These rods were largely used upon the Stephenson six-wheeled inside-cylinder engines, made by Sharp & Roberts, of Manchester, England. Fig. 10 represents the rod end used in England for inside-cylinder engines, and in the United States for outside-cylinder engines, with some slight modifications, such, for instance, as leaving the top and bottom edge faces of the straps level, and putting one set-screw in the rod end instead of two in the strap. In the United States the parallel rods are usually made with straps held by bolts to the rods, in which case the employment of jibs is dispensed with. The connecting-rods used on Bury's four-wheel coupled engines had a small bracket beneath the straps, and the keys had a projecting end with a screw beneath, so that by means of a nut each side of the bracket the connecting-rod key might be adjusted. A similar adjusting piece is sometimes applied to the keys of parallel rods in the United States.



CONNECTING-RODS.

CAST-IRON RAILWAY WHEELS.

THE manufacture of chilled cast-iron railway wheels is a very important industry in the United States, upon whose railway system of 75,000 miles no other class of wheel is employed to any great extent, at least for passenger and freight rolling-stock. There are a large number of cast-iron wheel works in the country, varying in capacity of production from 450 down to 40 or 50 wheels per day, and such improvements have been introduced into the manufacture that, whereas some time since railway accidents arising from broken wheels were common, of late years such a mischance is almost unknown. One of the most important improvements in the process of manufacture was introduced some years since by Mr. W. G. Hamilton, at one time actively connected with the Ramapo Wheel Foundry. It consists in mixing with the pig-iron a certain proportion of Bessemer steel, crop ends of rails being most conveniently used for this purpose. This mixture, besides improving the chilling qualities of the wheel, adds greatly to its strength, and even allows of the use of anthracite in the place of charcoal pig-iron. The Pennsylvania Railroad Company have erected large works at Altoona, where they manufacture wheels upon this system.

WHITNEY & SONS' CAR-WHEEL WORKS.

We recently visited the works of Messrs. A. Whitney & Sons, of Philadelphia, one of the oldest and largest establishments for the manufacture of chilled wheels in the United States, and where the different processes have been brought to a stage of high perfection. Built in 1847, the works present a remarkable appearance of solidity, and are well designed for the special purpose to which they are devoted. Although in the city the system of running trains through the streets gives direct railway communication to the works, the Philadelphia and Reading Company connecting direct to Messrs. Whitney & Sons' establishment to deliver material and carry away the finished wheels. Of course the foundry is the most important portion of the whole works. It is a fine building 450 ft. long and 50 ft. wide, with two lines of rails running down its whole length, except opposite the furnaces. The rails are laid to a gauge of about 10 feet, and upon them are placed twelve light travelling cranes, with a platform attached to the centre post, and upon which the man working the crane stands, and controls its movements, both in hauling the moulds and ladles, and in moving the crane from place to place upon the line, the crane being geared for travelling. The floor of the foundry is so laid out that there is room on either side of both pairs of rails for a row of moulds, and in the centre of the building is a path about 4 ft. wide. Against one side of the building, and in the centre of its length, are five cupolas, three of 4 ft. 6 in. internal diameter, and two smaller ones of 18 in. in diameter. The former of these are employed in melting the iron for the wheels, the latter chiefly for experimental purposes. The three furnaces are tapped into converging channels, all running into one large tipping reservoir from which the small ladles are supplied. The blast to the cupolas is furnished by a vertical blowing engine, with two blowing cylinders, one at the top of the machine and one at the bottom, with the steam cylinder between the two.

MIXING THE IRONS.

The mixing of the irons for the cupolas is the most important and difficult operation in the whole course of the manufacture. Besides the steel scrap—for Messrs. Whitney & Co. employ Mr. Hamilton's patent—nothing but charcoal pig-iron is employed, and of this from 12 to 20 different kinds, all of the highest class, are used in varying proportions. But these mixtures have to be altered frequently, owing to irregularities in the nature of the metal, and daily tests are made with a view of ascertaining what changes, if any, have to be introduced into the next day's work. The proportions of the mixture being decided upon, the cupolas are charged, a ton of coal being put first in the bed of each furnace. The charge is then carefully loaded upon trucks upon a weighing platform. Piles of the various pigs are placed in their proper order around the truck, and there is a drum upon the weighing machine, on which a sheet of paper is placed, and the weights of each different pig in proper order are written upon it. For instance, the workman commences with 250 lbs. of coal in his truck; he then places 125 lbs. of old steel rails, 125 lbs. of cinder pig, 350 lbs. of old wheels, and so on through the long list of charcoal pig-irons employed, the old material being placed at the bottom of the furnace The weighing platform is so arranged as to record the accumulating weights as the drum revolves, bringing before the workman the name and quantity of each successive ingredient which he takes from its respective heap before him. As soon as it is loaded the truck is raised to the top of the cupola by an hydraulic lift. The moulds when ready are placed down the building in four rows, one on each side of the two lines of rail upon which the cranes run. The patterns used are almost all in iron, and the chills in the moulds are of cast iron. One workman can, on an average, mould ten wheels a day, but all failures in the casting arising from any carelessness in moulding are charged to him on a rapidly increasing scale. This system has been found necessary, as the men are paid by the piece, and if only the price paid per wheel were deducted for the spoilt castings a far higher average of failures would result, because the

men earn higher wages by working faster and more carelessly.

METHOD OF CHILLING.

Before the metal in the cupola is ready to run, a charcoal fire is lighted in the receiver before spoken of, in order to warm it, and also that when filled the metal may be covered with charcoal and oxidation checked. In a similar manner the ladles, of which there are a very large number employed, have burning charcoal placed in them, and they are coated internally in the usual way. These ladles are cylindrical pots made of sheet-iron, and mounted each on a pair of wheels for facility of transport. On the sides of each ladle are two sockets, into one of which the end of a long iron handle is inserted for hauling it along the floor. Also at each end of the axle is a square hole, into which is placed the end of a handle with forked ends. The ladle being run up to the receiver, the latter is tipped over by the gearing attached to it, and the ladle is charged; it is then brought along the floor to the crane, which takes hold of it, the two square-ended handles before mentioned are inserted in the holes in the axles, the ladle is raised, and the iron is poured into the mould. The chilled portion of the wheel sets almost as soon as it comes into contact with the chills, and in a very short time after the casting has been made the flasks are removed, the sand knocked away, and the red-hot wheel is placed on a trolly to be taken to the annealing pits. This process is one of the most important of the series. If the wheel be allowed to cool in the open air, severe internal strains are created, which will sometimes be sufficient to destroy the casting violently, and open-air cooling was the active cause of failure in the early periods of this class of wheel-making.

METHOD OF ANNEALING.

The annealing ovens in Messrs. Whitney & Sons' works are placed at one end of the foundry and below the floor, the top of the ovens being at that level. Besides these ovens of very large diameters for extra-sized wheels, chilled tires, &c., there are forty-eight pits ranged in six rows of eight each. These rows are divided into pairs, each pair of sixteen pits being devoted to the reception of one day's production, the period required for annealing being three days. By this arrangement, when the last two rows of ovens are charged, the first two rows can be emptied and refilled, so that the work proceeds without interruption, and in regular rotation. Two hydraulic cranes, with the booms revolving upon a fixed post, are placed upon the floor, and command the whole area occupied by the ovens. The boom of each crank is made double, and upon it runs to and fro a small carriage, from which hangs the chain, carrying at the lower end the hooks by which the wheels are handled. This attachment consists of three arms, with flattened ends turned over so as to grip the wheel. The upper ends of these arms are hinged together, and as they tend always to fall inward, they hold the wheel tightly, but by moving a single attachment the arms are thrown outward when it is desired to release the wheel. The motion of the cranes is controlled by one man, fixed stops being provided on the guiding apparatus, so that when the crane is adjusted for filling one oven, it remains in that position till it is thrown over to the next.

The ovens or annealing pits are cylinders of sheet-iron ¼ in. thick, about 66 in. in diameter, and of sufficient depth to contain easily eighteen wheels with cast-iron distance pieces between them. They are lined with brickwork, and being of considerable length, they descend into a lower floor. The lower parts are enclosed in a large rectangular chamber, one for each set of ovens. Within this chamber, and for a short distance above it, firebrick is used instead of ordinary brickwork as in the upper portions, and within the cylinder a circular foundation of brickwork is set, upon which are placed the wheels on being lowered by the crane. The whole of this weight then is transferred direct to the foundation of the building. At the end of each of the three rectangular chambers already mentioned is a furnace, and each chamber is divided down the whole of its length by a perforated flue; through these perforations the heat from the furnace passes and enters the lower ends of the ovens. These furnaces are required to prevent the too sudden cooling of the castings, but only ¼ ton of coal is burned for each full day's production. Flues leading to the chimney carry off the heated gases from the upper part of the ovens, and so the process of cooling is thus very gradually carried on, until at the end of three days the wheels are ready for removal. The three large annealing pits mentioned above are somewhat differently arranged. To save room they are not carried down so low as the other ovens, but terminate at a height of about 7 ft. above the floor, each being supported upon a central column. When they are used a fire is lighted in the bottom of each pit, the wheels are placed in and covered over, and the oven is allowed to cool gradually.

TEST OF CAR-WHEELS.

On being removed from the pit the wheels are taken into the cleaning and testing room. Here the sand is removed and the wheels tested by hammering under a sledge as well as by a small hammer, while the tread is cut at intervals by a chisel. The heavy blows to which the wheel is subjected never fail in detecting faults when such exist, and when they are discovered the wheel is removed to be broken up. About 10 per cent of the whole production is rejected, but often this proportion is very much higher.

In order to keep the quality of the wheels to the desired standard, a large number of test pieces are cast every day and submitted to examination. By this means an accurate knowledge of the nature of the wheels, the character of the chill, and other points are obtained; the data are carefully recorded, and if the tests are satisfactory the wheels corresponding to the test piece are delivered into stock. If not, they are returned to be broken up.

BORING AND FITTING CAR WHEELS.

The sound wheels finally are taken to the machine shop, where they are bored, and, if desired, fitted with their axles. The tools, therefore, in this shop are few in number, consisting of three boring-machines, a press for forcing the wheels on, or for drawing them off the axles, and a number of lathes. The boring-machines were made by Sellers as long ago as 1848, and they have performed admirable work ever since. In two of these machines the wheels are placed in a horizontal chuck, consisting of a bottom plate, and a very strong iron ring, larger than the diameter of the wheel. At three equidistant points within the ring are three cams turning on vertical pins, and which can be all actuated together. At a single operation each cam is thrown out equally, and, as the centre of the chuck corresponds exactly with the centre of the boring-bar, the wheel is quickly and accurately centred as soon as it is placed in the machine, and the cams thrown against it. In the third machine the arrangement is somewhat different, an expanding chuck being employed to receive, centre, and hold the wheel. In each of these three machines eighty wheels can be bored per day of ten hours, the thickness of metal taken off being ⅜ in., and the length of hole 7 in.

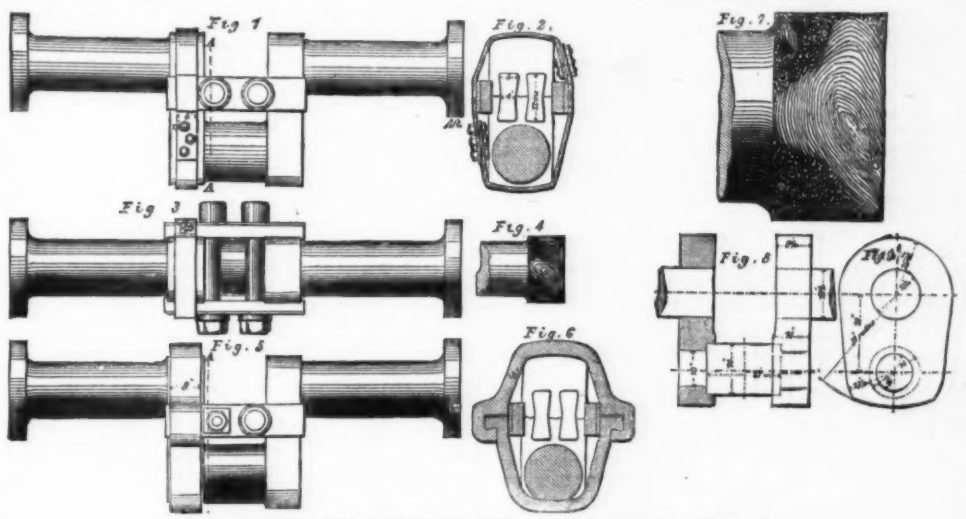
The tool for putting the wheels upon the axles is a simple screw press, and calls for but little notice. It may be mentioned, however, that it is furnished with a crosshead, upon which the axle rests, and which is raised and lowered by hydraulic power. The wheels are put on with a pressure of 42 tons. The capacity of Messrs. Whitney & Co.'s foundry is 250 wheels per day; at present they are occupied in filling a large order of small-sized wheels for the Denver & Rio Grande Railway. It should be mentioned that hydraulic lifting apparatus is employed throughout the works, the machinery for this purpose having been furnished by Messrs. Sellers.

LIFE OF CAR WHEELS.

The average life of a chilled cast-iron wheel of first-class quality is asserted to be 50,000 miles for passenger and 100,000 miles for goods traffic. If this be so, still the amount of renewals on the United States' railways is enormous, but we believe that this is a high average, and that most of such wheels fail before they attain this mileage. The common mode of failure is a breaking away of the surface of the tread in spots, until large portions of the chill become pitted in shallow holes. The exact cause of this failure has not yet been ascertained. In some cases such wheels are turned down to a smooth surface, and again placed in service.—*Engineering.*

HOW THE COLIMA'S CRANK-SHAFT WAS REPAIRED.

WE have received particulars of some repairs effected at sea during a run of the Pacific Mail Company's steamer "Colima" from San Francisco to Sydney in November last, which will, we think, be read with interest by many of our readers connected with marine engineering. The s.s. "Colima," we may premise, has a gross tonnage of 3000 tons, and a displacement at deep draught of 4800 tons. She is driven by a pair of compound engines having a high-pressure cylinder 51 in., and a low-pressure cylinder 88 in. in diameter, the stroke being 3 ft. 6 in. The pressure of steam used is 63 lbs. The vessel is fitted with a Hirsch propeller 16 ft. 6 in. in diameter and 23 ft. 6 in. pitch.



REPAIR OF THE CRANK-SHAFT OF STEAMER "COLIMA."

In November, 1875, the "Colima" left San Francisco for Sydney *viâ* Honolulu and Auckland, the run from San Francisco to Honolulu, a distance of 2087 knots, being made at an average speed of 10¼ knots per hour, the engines making 55½ revolutions per minute. The weather for the first five days was moderate, but with a strong beam sea, the vessel rolling heavily. On the 19th of November the "Colima" left Honolulu, the weather being fine with light airs and calms, and the engines making 57 revolutions per minute, and giving an average speed of 11¼ knots. At 1867 miles from Honolulu, however, a fracture occurred in the forward arm of the after crank, the fracture, as shown by the annexed sketches, running in an almost straight line across the arm close to the neck of the main journal. The appearance of the fracture (see Fig. 7) showed a very imperfect weld, the edges alone being really fractured, and the area of sound metal being only about 25 square inches. The grain of the metal was very coarse and crystalline.

Under the circumstances Mr. R. Forsyth, the chief engineer of the "Colima," decided to fit a spare shaft which had been in use before, but which had been taken out on account of a flaw in the crank-pin It was, however, considered serviceable and was therefore carried as spare. The change was effected, and after 70 hours' detention the "Colima" steamed ahead at an easy speed of 8¾ knots, the weather being fine and the engines making 49 revolutions per minute. Only 777 miles had been run, however, when the after arm of the low-pressure engine crank gave way, the break following the circle close to the main bearing, and as both engines were forcing the shaft round the broken crank rode over the corner of the piece left in the after bearing of the sole plate, and in doing this broke the base of the column and sole plate and also the other arm of the crank, when, of course, the smashing of the piston and cylinder cover followed, thus completely disabling the after or low-pressure engine.

To make the high-pressure engine do the work alone it was necessary to repair one of the shafts, and the one first broken was accordingly taken in hand and repaired by fitting in four double dovetail plates 5 in. by 1¼ in., as shown by the annexed Fig. 2, keeping the broken pieces in the meanwhile well together by means of two hydraulic jacks. Two clamp plates built of different pieces were then put longitudinally over the break, as shown by Figs. 1, 2, and 3; these clamp plates had ½ in. shoulders fitting snugly on each cheek of the crank, and they were fastened with the 4 in. crosshead bolts. A band of iron was then shrunk around the crank passing over the straps; this band was 5 in. by 1 in., made in two pieces with lap joints and three 1¼ in. bolts in each joint.

These repairs being effected and the shafts again changed, the "Colima" went ahead with the high-pressure engine after a delay of six days, the engine making 30 revolutions per minute and the speed obtained being 7 knots. The weather was fine, and after running 622 miles without further trouble the vessel arrived at Auckland on December 14, 1875. We should explain that the delay of six days, just mentioned, includes every thing from time of breakdown until starting again under steam, the actual time occupied in repairing the shaft being about three days. The shafts had to be taken from the hold, the low-pressure valve to be taken out and the ports blocked, the connecting-rod to be removed to give clearance, and the first long length of screw shafting had to be taken up and moved aft to permit the cranks to pass into the engine-room. Altogether the performance of the work in the time was most creditable to the energy of Mr. Forsyth and those under him.

Although the repaired shaft showed no signs of yielding, it was deemed advisable as further security on the ship's arrival at Auckland, to fit on a heavier strap in the place of the 5 in. by 1 in. one fitted at sea. This was done, the new strap being 8 in. by 3 in., connected as shown in Figs. 5 and 6, and with this the steamer proceeded to Sydney, a distance of 1290 miles, making an average speed of 8 knots, the engines running at 40 revolutions per minute. The "Colima" arrived at Sydney on the 25th of December, the repaired shaft having shown no signs of working at the fracture.

On the arrival of the "Colima" at Sydney, it was at first proposed that the Australian Steam Navigation Company should make two new shafts with their new 6-ton hammer, but the agents for the vessel ultimately entrusted the repairs to Morts Dock and Engineering Company, and ordered the shaft to be repaired in the manner shown by Figs. 8 and 9 annexed. A great difference of opinion existed among the engineers in Sydney as to whether the crank as built in this way could be depended upon, but while the job was in hand, the "City of San Francisco," a larger ship with similar sized cylinders, but much longer stroke (5 ft.) arrived at Sydney with all her cranks built in the same manner. We may add that since receiving the above particulars, we have also received letters which had been carried by the "Colima" to San Francisco, and we presume therefore that the shaft, as shown by Fig. 8, made the voyage successfully. As regards the other repairs effected at sea in the manner we have explained, we may repeat that the manner in which they were carried out reflects great credit upon Mr. Forsyth.—*Engineering.*

AERIAL NAVIGATION.

A MEETING of the Aëronautical Society of Great Britain was held on June 7 at the Society of Arts, Mr. C. Brooks in the chair. Mr. Brown read a paper on "The Advantages of Employing Power in the Intermittent Manner, with special reference to the flight of birds," and exhibited models of portions of an apparatus for aërial propulsion. The Hon. Sec. (Mr. F. W. Brearey) next read a paper by Mr. James Armour, "On Air Compression under Winged Planes," which dealt learnedly with motions of displacement and compression, cushions of resistance, angles of inclination, velocity of rotation, and other technicalities of aërial science, the author's remarks being illustrated by diagrams of numerous circles and curves. On the conclusion of the reading of the paper a member offered some explanatory observations, showing that one of the diagrams represented a wheel with floats, like the floats of a paddle-wheel. The secretary then exhibited a miniature flying-machine, which appeared to consist of two pairs of wings attached to an arrow, with a rudder-like tail, and which was wound up by twisting the tail round a certain number of times. When released, however, the machine would not fly, and a second attempt also proved a complete failure.

The secretary attributed these ill results to some trifling derangement of the apparatus, and the next business was then proceeded with. This was the reading of a paper by Mr. Thomas Moy, who spoke unfavorably of balloons, or "gas-bags," as compared with mechanical flying-machines, which he thought would ultimately solve the problem of safe travelling through the air. He had elaborated an idea for the construction of a flying machine, to weigh 1120 pounds, to be worked by a steam-engine weighing 600 pounds, and to travel 200 miles an hour "as safely as a railway train." Mr. Moy exhibited a couple of very ingenious models of air-fans, moved by clockwork, and also a pair of small balloons, lent by Mr. Coxwell, who was present. Mr. Moy announced that he was making a 30-horse-power steam-engine, with which he intended to take two aëronauts up vertically, and when he had got them up vertically he would soon arrange the horizontal movement, which was much easier. He thought the best chance of success was to start with the steam-engine, because he had proved at the Crystal Palace that 120 pounds weight could be lifted with a 3-horse power. He had not much faith in experiments with springs and clockwork, which generally stopped just as as you were getting the thing right. Mr. Brown said he, too, should like to see his scheme tried on a large scale. As to the difficulty of balancing, Mr. Brown believed he had overcome that.

ASTRONOMY.

THE June meeting of the Royal Astronomical Society was held at Burlington House on the 9th. Wm. Huggins, Esq., D.C.L., President, in the chair.

REFLECTOR VS. REFRACTOR.

Dr. Mann was called upon to give a verbal account of a comparison which he had instituted between the performance of a 3½ in. achromatic, by Ross, and a 6½ in. silver-on-glass reflector, by With. It appeared that the comparison had only been made as to the definition of objects upon the moon. Dr. Mann was of opinion that he could see nothing with the 6½ in. reflector that he could not also see with the refractor, and that the shadows of objects as seen with the refractor were distinctly blacker than those seen with the reflector, which he described as being all of a neutral tint.

Mr. Wentworth Erck said that he had had an opportunity of comparing two telescopes of more nearly the same aperture —namely, a 9 in. reflector and a 7½ in. refractor. He could corroborate Dr. Mann's statement as to the greater darkness of the field in the case of the refractor than in the case of the reflector. The reflector, however, gave smaller and sharper disks for stars, and consequently was better suited for separating minute double stars.

The Astronomer Royal said that he had the good fortune some years ago to test one of Cauchoix's great reflecting telescopes at the Paris Observatory. It was necessary, in order to make it perform well, to blow up a bag of air in the cell behind the reflector, but when the air was blown in so as to give a proper tension to the speculum, the definition was better than that of any other instrument he had ever seen. There was no doubt that in the reflector there was only the geometrical condition of one surface to consider, while in the refractor there were four surfaces and also the irrationality of the dispersion of the two glasses, which could never be made properly to balance one another.

Mr. Lassell said that he had only had short experience in testing the performance of silver-on-glass mirrors, but with those he had seen there was certainly want of blackness about the shadows, such as had been described by Dr. Mann. With metal specula, however, the shadows were as black, indeed blacker, than with any achromatic.

Professor Pritchard said :—We have at Oxford two instruments of nearly equal aperture, the one a reflector, and the other a refractor—the reflector 13½ in. and the refractor 12 in. Our experience entirely coincides with what Mr. Lassell has said as regards the blackness of the shadows, but the doubt I have as to the superiority of the reflector to the refractor is this, that you can rarely use the reflector. Whatever the cause may be, the currents of air or the alterations of heat, it rarely comes up to its best performance, and we have always to revert to the refractor as the practical instrument. It is not very long ago since I was with Mr. With at Hereford, who I presume has produced as fine mirrors as any that have ever been produced. Mr. With, with all his experience, has continually to go to the mouth of the tube and blow with a fan in order to do something or get rid of some thing that affects the definition, and as soon as he has blown with his fan the definition becomes marvellous again ; but it only lasts for a minute or two, and then the blowing has to commence again.

Mr. Lassell said :—With respect to the uncertainty of specula, I believe it has chiefly to do with flexure. A speculum, whether small or large, requires to be supported in all directions, so as to enable it to be turned rapidly from one position to another I know it is the case with my 2 ft. speculum. If I turn it, it may be five minutes before the speculum will come up to its proper excellence.

The Earl of Rosse said :—It appears to me that what has been noticed by Dr. Mann admits of easy explanation. If there is the least degree of tarnish on the mirror there will be a diffused light over the whole image. In the case of the reflector, tarnish or want of polish casts back the light in all directions into the eyepiece, while in the case of the refractor, tarnish will only throw the light back toward the sky—in fact, to use a coarse illustration, if you were to stick a number of pieces of white paper on the outside of an object-glass, you would only diminish the light ; but if you were to stick the same pieces of white paper upon the surface of the reflector, you would get a diffused light all over your field. Silver-on-glass reflectors rapidly get slightly tarnished, and it is not noticed, because the definition of the instrument is not affected thereby.

Dr. Mann said that the reflector he had used had just been re-silvered, and was perfectly brilliant. He was perfectly sure that the diffusion of light could not have been owing to tarnish—it might have been due to some molecular condition of the silver.

INEQUALITY IN THE MOON'S LONGITUDE.

Mr. Dunkin read a paper by Prof. Simon Newcomb, "On a Hitherto Unnoticed Apparent Inequality in the Longitude of the Moon." The inequality was, it appeared, brought to light in the course of an investigation which has recently been made by Prof. Newcomb, of the corrections to be applied to "Hansen's Tables," in order that they may be used for the determination of longitudes for the Transit of Venus stations. Prof. Newcomb had set himself to compare the places derived from "Hansen's Tables" with the series of lunar observations made at Greenwich and Washington, between the years 1862 and 1874, and the residual errors of the moon's place were then corrected for the theoretical terms in which the tables seem to need emendation. When the several emendations and the errors of the moon's semi-diameter had been applied, Prof. Newcomb was surprised to find that the residual errors showed a systematic outstanding inequality which could not be got rid of by any new assumption as to the value of the corrections of the lunar elements. There could be no serious doubt about the inequality, because both Greenwich and Washington observations agree in showing it. A close investigation also showed that the errors were periodic, and depended on the moon's longitude, being positive when the longitude was between 180° and 360°, and negative in the other semi-circumference. In order to make the investigation more complete, Prof. Simon Newcomb determined the corresponding corrections for the years between 1847 and 1858, for which the residual errors of "Hansen's Tables" are given in the Greenwich Observations for 1859. A table of the resulting corrections is given in the paper. The period of the chief term of the new inequality is 16½ years, with a probable error of half a year. The corresponding period of the inequality in longitude is 27.4304 days ± 0.0040d. ; and there is a large preponderance of probabilities against the real period being less than 27.42 days, or more than 27.44 days. No known term in the moon's longitude falls within these limits. The moon's sidereal period is 27.32 days, and the anomalistic period is 27.55 days—so that the new term falls half-way between the two. The non-accordance of this period with any term heretofore sought for is the probable reason why this term has not before been noticed. A term, if unknown, would not be remarked, unless its magnitude was such as visibly to affect the individual comparisons of theory with observation ; and "Hansen's Tables," as corrected, are the first ones of which the residual errors are so small that a term of 1.5" would be remarked in the comparison with observations.

Professor Adams was called upon by the President. He said :—I must apologize for saying any thing on such a subject on the spur of the moment. I am certainly at a loss to imagine what the cause of this inequality can be. I am rather inclined, at the first blush, to suppose it may have something to do with the effect of the figure of the earth on the motion of the moon ; but this is merely an idea thrown out on the spur of the moment. It will require a very accurate examination of the theory to say what the inequality is due to.

The Astronomer Royal :—I can certainly think of nothing which can be held exactly to explain this inequality ; but I do not by any means wish to depreciate the production of a reduced series of observations like this. It has been by comparisons of observations with theory that every step in the mathematical theory of the moon and planets has been made. It was by observation in the first place that the eccentricity of the moon's orbit was determined. It was by observation that the great inequality in the motion of Jupiter and Saturn was determined before it was accounted for theoretically, and so it has been that every step in the lunar theory has been made. When I look upon these things I am inclined to think that, after all, theory is a very poor matter indeed. This paper of Professor Simon Newcomb's is one of those things which is likely to spur on us theorists to attempt to account for the observed fact ; but at present I certainly do not see in what direction of the theory the fact points.

IMPROVED ALTAZIMUTH INSTRUMENT.

Lord Lindsay exhibited an adaptation to the ordinary altazimuth instrument, designed to give a rough equatorial motion. To the base of the altazimuth pillar is fixed an iron bar, through a hole in which a string or wire is attached to the object-glass end of the telescope ; the only adjustments that are necessary are that the horizontal bar shall lie approximately north and south, and that the distance from the base of the altazimuth pillar to the hole in the bar—through which the string passes—shall be equal to the height of the pillar into the co-tangent of the latitude of the place of observation. Lord Lindsay said that the contrivance was so simple that he could hardly conceive that it could be new, but as he had not heard of any thing of the kind before, he thought it right to bring it before the meeting. (Applause.)

THE LIGHT OF VENUS.

Mr. Plummer read a paper on photometric experiments upon the light of Venus, by comparing the shadow of a wire cast by the light of the planet with a shadow of a similar wire cast by a candle at a known distance, and again by comparing the light of the candle with the light from the full moon, he came to the conclusion that the light of Venus at its greatest brilliancy was equal to $\frac{1}{7593}$ of the mean brightness of the full moon ; by a similar method he found that the light of Jupiter at mean opposition was equal to $\frac{1}{5449}$ of the light of the mean full moon.

SPECULAR REFLECTION OF VENUS.

Captain Noble read a note on the alleged specular reflection from the body of Venus. After a careful examination of the planet with various powers and apertures he was unable to detect any traces of the specular illumination described by Mr. Brett, and on extinguishing the light of the planet by means of a wedge of dark glass, he found that the first portion of the planet to disappear was the area near to the terminator. The points of the cusps then appeared to become blunted, and finally the whole of the rest of the illuminated disk of the planet appeared to be extinguished at the same instant. There was certainly no patch of brighter light within the limb, as described by Mr. Brett.

MOTION OF BRIGHT SPOTS ON JUPITER.

Mr. Brett read a short paper on the proper motion of some bright spots which he had observed upon Jupiter. From eye estimations of the positions of the spots made upon four occasions, he thought that he had detected a proper motion of the spots upon the surface of Jupiter equal to 165 miles per hour. The meeting adjourned at ten o'clock.

FRENCH ACADEMY OF SCIENCES.

JUNE.

On the Absorption of Free and Pure Nitrogen and Hydrogen by Organic Matter. By M. Berthelot.—White filtering paper lightly moistened and in presence of pure nitrogen, absorbs the latter under the influence of the electric discharge (silent) in notable quantities, in from eight to ten hours. It suffices then to heat the paper highly with lime to disengage therefrom a large quantity of ammonia. The presence of oxygen does not hinder this absorption of nitrogen. It results from these facts, that the fixing of nitrogen in nature is not necessarily correlative to the formation of ozone, or to the previous production of ammonia or nitrous compounds. The intervention of atmospheric electricity appears to modify these conclusions, and to connect the results which occur at the surface of the soil with those previously observed by the author, taking place under the influence of the electric discharge.

Under the last-mentioned influence, hydrogen also is absorbed, and even more rapidly than nitrogen. .061 cubic inch of benzine has absorbed 4.2 cubic inches of hydrogen, or about 2 equivalents ; essence of turpentine has absorbed 2.5 equivalents of hydrogen with formation of resinous products almost solid and polymeric.

On the Formation and the Decomposition of Binary Compounds by the Electric Discharge. By M. Berthelot.—It has long been known that under the influence of the electric flow a commencement of combination of nitrogen and hydrogen occurs. It suffices to introduce into the gases a bubble of hydrochloric gas to determine the formation of abundant smoke clouds. If the electric spark be transmitted in presence of dilute sulphuric acid so as to cause absorption of ammonia, a considerable quantity of the latter may be collected after the lapse of sufficient time. M. Berthelot, by the action of the electric flow, has succeeded in decomposing protoxide and binoxide of nitrogen, sulphuretted hydrogen, etc. He reaches the following conclusions : The action of the flow, like that of the spark, tends to resolve the composite gases into their elements, with production of phenomena of equilibrium due to the inverse tendency of recombination. In the case of the flow, one portion of the elements unites itself to the composite gas to form condensed products ; these are not produced by the spark. According to the author's experiments in the decomposition of formene by the spark, about ⅓ of the gas changes into condensed carburets. In principle, the two reactions are the same, but the unequal duration of the heating appears to be the cause of the variations observed.

On Large Solar Photographs. By M Janssen.—Daily photographs of the sun are now made at the Montmartre Observatory. The solar disk has been photographed 8.5 inches in diameter, with great clearness. The spots, faculæ, and granulations are distinctly marked, and are of sufficient size not to be obscured by the grain of the paper. The solar surface at the present time is completely free from spots, this being the epoch at which the same are at their minimum.

On Amber. By M. Reboux.—At the Eocene epoch the bed of the Baltic Sea was occupied by an immense forest, which spread over nearly the whole northern continent. Dredging carried on at a depth of 6.4 feet below the sea-bottom has brought to light thereby two species of conifers, a poplar, a chestnut, and various other trees. From the conifers, the author thinks, ran the resin which, through being buried in the earth, has become changed into amber. The largest quantity of the gum appears to have been derived from the *Pinus succinus*. More than two hundred specimens of objects have been found imbedded in the gum, including insects, reptiles, plants, leaves, grains, shells, fruit, etc. The density of natural amber varies from 1.09 to 1.11. Its analysis, according to Schrötter, is : carbon, 78.82 ; hydrogen, 10.23 ; oxygen, 10.90.

On the Law of Dulong and Petit. By M. Terreil. (See SUPPLEMENT, No. 30.)—The author concludes that Dulong and Petit's law, regarded as a chemical law, may be defined as follows : 1. The product of the specific heat by the chemical equivalent is a constant, with the conditions that all bodies may be taken under the same gaseous volume and before condensation. 2. The specific heat of simple bodies, taken under the same volume of gaseous state, is inversely proportional to their chemical equivalents. 3. The specific heat of compound bodies taken under the same volume at gaseous state is inversely proportional to their chemical equivalents, and proportional to the condensation to which the gaseous volumes of the elements which constitute them have submitted in combining. 4. Simple or compound bodies which have lost the gaseous state have specific heat which is double that possessed while gaseous.

IMPROVEMENT IN FATTY INK PRINTING FROM GELATIN.

By Mons. LÉON VIDAL, communicated to the French Society of Photography.

"AT the moment when the magnificent exhibition of photography at Paris proves beyond doubt that a very great progress has been accomplished in collotypic printing, any thing, ever so little as it may be for the amelioration of that process, must be acceptable. This is why I come forward, believing that I shall render service to many in describing a simple means of retouching gelatin films from which photographic proofs are to be printed in fatty ink.

"Those who occupy themselves with fatty ink printing, from bichromated gelatin, employ for that purpose patent plate-glass, and as soon as the proof is obtained on its surface they rarely attempt to modify it, so that if the image require a frame, a second operation, from a lithographic stone, is necessary in order to obtain it.

"The same operation is necessary if a signature, description, etc., is to be printed at the bottom of the page.

"It is very often found necessary to retouch the gelatin film in certain parts, where details are absent, and in others where white spots are visible.

"I have succeeded in this by the employment of a chemical agent having the same peculiarity as light in the insolubilization of that organic matter in presence of a chromic salt.

"I obtain this result with gallo-tannic acid, and even common ink containing a small quantity of tannin will do as well. After isolation, and even after the necessary washing, any design can be drawn upon the film; a signature or any thing else can be written and then printed off without trouble.

"The surface of the glass is so flat and even that the most delicate design can be drawn upon it. This will be found of great value for the decoration of proofs with their frames, which can be drawn by hand around them.

"Typographic transfers can be obtained as easily as upon stone by employing a thin ink containing tannin.

"To sum up, this process enables the operator to draw from a bichromated gelatin film either a view, portrait, photographic proof, or a linear design, signature, etc.; in fact, all that can be obtained from a lithographic stone, and what is more, a photographic proof and a lithographic drawing can be obtained at the same time.

"Different tints and shades can be obtained by employing tannin in different degrees of concentration. This will give from a light gray to a jet black."

PHOTO PLATE-CLEANING SOLUTION.

MIX alcohol, ½ ounce ; acetic acid, ½ ounce.

To clean the plate, drop a few drops of this on it (about four for a quarter-plate) and rub it all over with a piece of rag until it ceases to bite; then polish with a silk handkerchief or piece of wash-leather, and the plate will be found to be beautifully cleaned.

This method is especially useful on account of the plate requiring no washing, and also it cleans it better than the ordinary way with tripoli, and takes about half the time, and there is no fear of getting particles of tripoli into the bath.

UTILIZING THE WASTE HEAT OF STEAM BOILERS.

THE improved apparatus invented by Mr. James Wilson, of Ossett, near Wakefield, England, is constructed with a capacious water space, into which project recesses of a height equal to that of the boiler-flues, and of a width exceeding the height thereof. Through these recesses are passed tubes arranged in a vertical direction. The recesses are surrounded on all sides but the front with water space, and the tubes serve to effect a circulation of the water. The said apparatus is set close against the rear end of the boiler-flues in such a manner that the products of combustion pass therefrom into and around the said recesses, and return therefrom to and along exterior side flues formed along or around the boiler.

THE BRITISH FRIGATE "HUSSAR."

WORK upon the wreck of the British frigate "Hussar," sunk in the East River during the Revolutionary war, has been resumed, after a suspension of three years. On Thursday last the sloop "Tent" was moored over the wreck, which lies in the north-eastern part of this city a short distance below Port Morris and within a stone's throw of the shore. In a frame structure on the deck of the sloop is a steam-engine and other machinery used in submarine work. The diver is lowered to the wreck from a platform on the shore side of the vessel. He made his first descent on Saturday morning for the purpose of making a general survey of the wreck. He found but little left of the old frigate. All that remains is the worm-eaten keelson, knees and planking below the copper line. The wreck is covered with a heavy deposit of sand and mud, and several large boulders have lodged in her hull.

The 'Hussar" was 206 feet in length, 38 feet beam, and carried thirty-two guns. She arrived in the port with the frigate "Mercury" and a fleet of merchant vessels on November 23d, 1780. In the "Hussar's" treasury were £380,000, gold, and on the "Mercury were £380,000, making nearly $3,000,000 in all. This treasure was sent over by the British Government to pay the forces engaged in waging war on the colonists. Two days afterwards the gold brought over by the "Mercury" was transferred to the "Hussar," with which, after taking on board seventy American prisoners from the overcrowded hulks in the "Wallabout," she set sail for New London, Conn. Paul Jones was at the time cruising along the American coast. His feat off Flamborough Head a year before had inspired the commander of the "Hussar" with a healthy respect for his powers, and it was therefore determined to make the voyage by the way of Hell Gate. It was a hazardous undertaking for a vessel of her tonnage, but a negro pilot had succeeded a short time before in taking through another frigate. The "Hussar" attempted the passage with a favoring wind and a high tide, and safely passed the most dangerous points in the channel, but with a smooth course already in view the frigate struck heavily on Pot Rock. The swift current swung her around, and she drifted helplessly up the stream, past Ward's and Randall's Islands, making water rapidly. When the vessel once more obeyed her helm she was filling so fast that the commander determined to beach her at the entrance to a marshy cove below Port Morris. This was done, and the crew, with the assistance of farmers at work near by, held her to the shore by passing hawsers around the large trees there. A more dangerous point could not have been selected, for the frigate from amidships hung over a precipice nearly one hundred feet high. When the tide began to fall the strain upon the cables was tremendous. Some parted, others pulled from the ground the trees to which they were attached, when the ship gave a lurch and went bodily over the ledge. Worst of all, she carried down with her the seventy hapless wretches chained to her gun-deck. The officers and crew escaped.

In 1794 the British Government sent over two brigs, and for two summers unsuccessful efforts were made to raise the sunken frigate. One of the brigs foundered while engaged in this work and now lies in thirteen fathoms of water a short distance below the hull of the "Hussar." The other was driven off by the American Government. Twenty-five years elapsed before another effort was made. A company was formed and work was begun in the spring of 1819; but with the clumsy appliances then in vogue no progress was made. One enterprise succeeded another, but with a like result. Over $50,000 was expended in constructing a coffer dam, which proved too weak to resist the force of the tide. Over twenty years ago a company was formed in Worcester, Mass., called the New-England Submarine Company, with Horace Barnes as Superintendent. This company and its successor, the Frigate "Hussar" Company, have prosecuted the work since, except during the three past summers. They have now resumed operations and hope by the use of improved machinery and a new process to get possession of the golden treasure buried in the frigate's hull. Mr. Barnes still superintends the work.

But little money has thus far been taken from the wreck, and the sums found are supposed to have been the private hoards of officers and men. In a stable at Port Morris are stored human skulls and bones, and manacles worn by the drowned American captives, together with musket barrels, cannon-balls, flints and bullets, pewter plates, etc. The British Museum paid $1500 for a bronze gun. In the Central Park Museum are other mementoes of the wreck. Obstacles to be overcome are numerous and great. The ship's treasury was located in the run of the vessel. The kentledge (iron) and shingle (stone) ballast have by the action of the water become joined together in a mass almost as dense as cast-iron. This mass overlies and surrounds the treasure, and has to be drilled or blasted through. Eternal night reigns around the wreck. Electric lights have failed, and owing to the swift tides divers can work only at slack water.

One of the divers engaged for the present season is Mr. Cook, of San Francisco. Mr. Cook is one of the most expert and successful members of his profession. His operations along the Pacific coast have achieved for him a reputation for daring and sagacity which has preceded him.

Among the well-known divers who have within the past twenty-five years worked upon the wreck of the "Hussar," Daniel W. Joshlyne has probably made the largest number of descents. He has also remained upon the wreck for a longer period than any other diver, having on one occasion stayed below for two hours and fifty-five minutes. Messrs. E. B. Eaton, Thomas O'Neill (deceased), Otis A. Ramsey, Uriah Card and Mr. Whitney are the other divers best remembered.—*New-York Herald*

IMPERIAL CELERITY.

RECENTLY, the Emperor of Brazil gave another instance of his desire for examining industrial establishments, and of his remarkable faculty for accomplishing a great deal in a brief space of time. At the invitation of Hon. Asa Packer, President of the Lehigh Valley Railroad Company, he made a visit to the portals of the Lehigh Valley, accompanied by a small party named in a letter from Bethlehem. He had made his customary visit to the Centennial Exhibition early in the morning, spending about two hours there, and at half-past nine took a special train at the Centennial Depot of the Pennsylvania Railroad, arriving at Bethlehem at eleven o'clock, after a run of but one hour and a half through the beautiful agricultural districts of upper Philadelphia, Montgomery, Bucks and Northampton counties. At Bethlehem the party was joined by several gentlemen connected with the Faculty of Lehigh University, by a number of Brazilian students at that College, and by several officers of the Lehigh Valley Railroad Company. The first visit was to the University, where the Emperor spent about an hour, apparently with great satisfaction, in passing through the class rooms and lecture rooms, examining the chemical laboratory (he being familiar with chemical science), the Observatory and other portions of the buildings, and in conversation with the Faculty and the young students from Brazil, who were very much rejoiced to see the ruler whom they and the people at home love so well. The young men gathered about him as they would around a father, and he seemed like a father in his conduct to them.

After leaving the University, the party was conducted to the Lehigh Zinc Works, in Bethlehem, where again the Emperor showed himself familiar with the science and art embraced in this important branch of metallurgy. The whole process was examined, from the first treatment of the ores (procured from the famous mine in the immediate vicinity) through all the operations of "roasting," subliming, melting, etc., to the final exit, where the coarse earth comes out in the form of the lustrous white oxide of zinc, now in such general use for indoor painting in dwelling-houses, and in its other forms of the spelter and sheet zinc of commerce. At this establishment he made inquiries about every thing, and expressed his desire to "see every thing" connected with the works. After exhausting the field of investigation there, he was escorted to the Bethlehem Iron Works, a great establishment, engaged now in the manufacture of steel railway bars. The steel ingots are made in the works by the Bessemer process, and two "converters" of steel, each of about six and a half to seven tons, were run while the party was present. With the chemical and mechanical principles upon which the Bessemer process is based the Emperor was also entirely familiar, yet still he closely observed the practical operation of turning one "converter," full of pig metal, into steel ingots, with manifest interest. The rolling of the ingots into steel railway bars was the next subject of examination, and finally, although the heat from the furnaces and near the rolls was intense, he went through the whole establishment with an interest that continued to the end. The Bethlehem Works have a capacity of about a thousand tons of steel bars per week, and of about 1500 tons of steel and iron together. Following this he took a run of ten or a dozen miles up the Lehigh Valley, stopping at the immense "Thomas" Iron Works, at Hokendauqua, where there are furnaces with a capacity for making eighteen hundred tons of pig metal per week, and where there are five enormous beam engines, for blast and pumping purposes alone, two of which (built by I. P. Morris & Co., of this city) are still more ponderous than the great Corliss engine in Machinery Hall. The Emperor went through the greater part of this establishment also, making particular inquiries about its operations, and was greatly interested. Having thus in part of one day made a visit to the Centennial Exhibition, travelled between sixty and seventy miles, visited a university and three extensive industrial establishments, the Emperor returned to his train, dined in the car, left Bethlehem at five o'clock, reached the North Pennsylvania Depot at 6.20, and was at the Continental Hotel at seven, to make ready for his engagements for the evening.—*Philadelphia Ledger.*

SCIENCE IN SCHOOLS.

PROF. HUXLEY lately delivered a lecture on the method of teaching science in schools to the Edinburgh Local Branch of the Educational Institute of Scotland, in the Watt Institution, Chambers street, Edinburgh. Mr. Maurice Patterson presided, and there was a large audience. Prof. Huxley commenced by showing how the teaching of science was carried out when the object of the teacher was simply to teach science, and when he was embarrassed by no other consideration. The system of teaching science, like all wholesome things, had grown out of practical necessities. In almost all cases science was an outcome of an art. People had begun to feel the necessity of systematizing the rules of the art, and for developing them to their furthest extent, and those rules had become what we now termed science. This was eminently the case with the science, the teaching of which first became properly organized—the science of anatomy. They must not trust to the teaching merely, and to the advantage gained from its being supplemented by books or aided by diagrams. In order to have the kind of knowledge which was real and could be depended upon, it must be acquired by the person taught going over the matter which he had to know for himself, and learning it at first hand. To this end were dissecting-rooms established, where the student himself verified what he had been told. Scientific teaching was in a great measure the acquainting the man with the laws which govern the phenomena of nature; but, in addition to this, there was about it the value of educational discipline. The first importance of its value in this sense was the fact that it cultivated the faculty of observation. He knew of no pursuit which was so competent to conduce to culture as science. The tide in favor of the introduction of science into schools was flowing as fast as it could, and if those who opposed themselves to it did not get out of the way they would be swept away. The extent to which they might carry this teaching of science would, of course, depend entirely upon the time allowed. He would be quite content with an hour. In conclusion, he observed it was most necessary that the person who teaches should know what he was teaching. On the motion of Prof. Hodgson, a vote of thanks was passed to the lecturer, after which the meeting separated.

CHINESE MONEY.

THAT the Chinese were a civilized and polished people when the inhabitants of the British Isles were but painted savages is an established fact. We have shown, too, that among the inventions to be attributed to these ancient *sæcans*, banknotes, or "greenbacks," must be included. In truth, the Chinese of two thousand or three thousand years ago practised, in their legislation, many of the arts and much of the financial jugglery which are now occasionally resorted to by modern Ministers of State in countries much nearer home than the Celestical Empire. Some "wrinkles," indeed, may be gained from a study of the history and the writings of the "pigtails" of the olden time. It is a remarkable circumstance, for example, that, although the science of exchanges and the bearing and effects of currency enactment are understood by very few statesmen of the present day, yet that the legislators of ancient China were apt and keen in these directions. Very early, indeed—long before their use for the purpose in Europe—coins, made of iron, of lead, copper, tin, silver, and gold, were manufactured and circulated in that marvellous, and well-named, "flowery" land. Some of this money, still in existence, is of such high antiquity that the most learned natives are unable to decipher the inscriptions upon it. One coin bears a strange device, with the legend—"Money has its course; at last it returns to the emperor." This was by no means an inappropriate inscription, for the practice prevailed, when the Imperial Treasury became empty, of recalling the money and recoining it at a greater nominal value. This, it will be remembered, is exactly what happened in respect of the old copper and new bronze coinage of our own time. One farthing's worth of bronze now passes at the nominal value of one penny. So that in this matter, as in many others, we have but "torn a leaf" out of the Chinese book, and might have used a similar legend as "money has its course, at last returns to the Queen." In respect of the precious metals, the Chinese discontinued using them for coinage purposes at a very distant date. For commercial purposes large transactions were "cleared" by weight, and for smaller transactions "mud money," as it was termed, came into use. These remarkable samples of mintage were composed of a species of clay, mixed with some kind of strong cement or glue. These oblong discs of pottery—for such in shape and appearance they were—were stamped while in a plastic state with figures and characters, and afterwards baked. For its regularity as a mark of value, mud money was much esteemed by the traders and traffickers of the period; and it only succumbed at length to paper certificates of indebtedness, or celestial I O U's, then known popularly as "flying money." In our own country at the present date money is frequently made to "fly." Possibly the expression is as old as the institution of flying money in China.—*London Iron Trade Exchange.*

LIGHTNING FREAKS.

ON June 7 a violent thunderstorm occurred at Valbonne, a large plain at a little distance from Lyons. The only objects struck were huts full of soldiers and arms, and the occurrence furnishes a good instance of the "power of points" and the attracting power of metals and living beings for lightning. Three tents were struck in succession. The occupant of the first was absent at the moment, and the effects were relatively slight, producing only the breaking of stones and dispersing of dust. In the second instance a soldier who was standing erect in front of one of the tents was struck; but the tent being located in the vicinity of an electric telegraph the lightning escaped by it, fired the wires, and broke a dozen poles. This may suggest a very easy method for protecting an encampment. The third flash struck a number of tents placed in a zig-zag line, doing much damage, several of the occupants being either killed or wounded. In one tent three men were killed and seven wounded. All of them were either touched in both legs or on the right side except one, who was wounded in the right eye. In another tent four men were wounded, all of them in both legs or in the left one. In other instances men were turned round in or heaved out of their beds. In all the instances referred to the men were lying on their beds, made of iron, and the sentry standing in front remained unhurt. In one tent a man, who was lying between two men who were killed, escaped unhurt. The uniforms of the soldiers were perforated and exhibited small spots; one, four centimetres in diameter, entirely sulphurized. A chemical analysis will be made of this part of the uniform, and the result communicated to the Academy of Sciences.—*Nature.*

LAKE NYASSA, AFRICA.

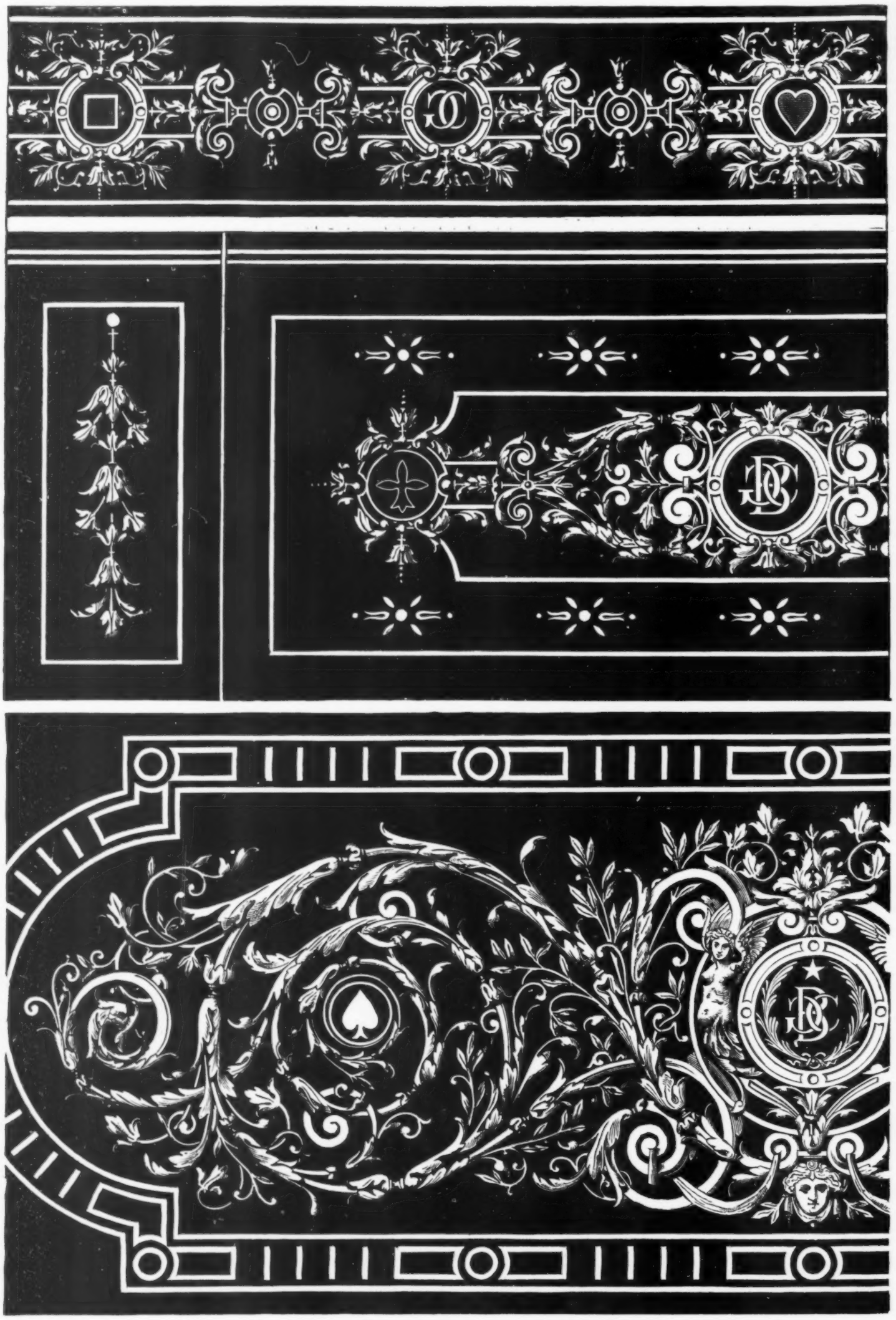
AT the meeting of the Royal Geographical Society lately, Sir Rutherford Alcock, the new President, in the chair, a paper by Mr. E. D. Young, R.N., was read, on a journey to the northern end of Lake Nyassa. The cruise round Lake Nyassa had occupied a month, and the area was much larger than Dr. Livingstone thought, the north end extending to 9.20 S. lat. In most parts it was very deep, and in several places no bottom could be found with 100 fathoms of line. A range of mountains nearly 100 miles in length, extended above the lake, some reaching an elevation of 10,000 or 12,000 feet. There were also numerous rivers running into the lake, but none navigable for any distance. At some parts there were numbers of villages built on piles in the lake; many people in other parts living on barren rocks. Mr. Young added that he intended to be back to England in a few months, and would in the meanwhile make a more perfect survey of the lake and give the results to the Geographical Society on his return. A paper on "The Valley of the Tibagy, in Brazil," by Mr. T. B. Wither, C.E., was also read. The author of the paper was engaged in conjunction with others, in August, 1871, in exploring that section of the Ivahy Valley which lies between Colonia Theresa and the Corredeira de Ferro, or "Iron Rapid."—*Nature.*

NEW GALVANIC BATTERY.

DR. ROBERT NEWMAN, of New-York, lately introduced to the State Medical Society a new element, consisting of zinc and gold upon lead. It was maintained that batteries containing elements made in that manner possessed twenty-five per cent more force than either the Dawson, the Byrne, or the Bunsen battery. The doctor did not exhibit a battery, but presented four pairs of elements, simply for the purpose of showing the initial force of each. A battery constructed upon this plan would cost thirty-five dollars.—*Medical Record.*

REMEDY FOR LOCKJAW.

DR. JOHN IMRAY reports most favorably on the effects of the simultaneous use of opium and chloral hydrate in cases of tetanus, both idiopathic and traumatic. In the tropics this disease exhibits a frequency and a virulence unknown in more temperate regions, and with the sole exception of hydrophobia, there is perhaps none so unsatisfactory as regards treatment, or so painful to witness (and usually so fatal) as tetanus. Hence the doctor's mode of treatment promises to be of great value. Three cases were treated successfully by the new method—namely, keeping the patients almost continually under the combined effects of chloral hydrate and opium tincture until all tendency to the recurrence of tetanic spasms had disappeared. As it generally happens that all power of digestion is lost in this disease, it becomes necessary to administer both the medicine and food by means of an enema. The power of these combined drugs in controlling and repressing the tetanic spasms is indeed very remarkable, and Dr. Nicholls, who had the patients under his charge, likens it to the action of a heavy weight on a spring, which, if the pressure yielded, the spring began to rise, but being continually maintained, the morbid nervous phenomena gradually gave way, and the disease was finally vanquished. It is suggested that the administration of these two medicaments by enema in hydrophobic cases might probably be followed by favorable results.



ORNAMENTAL CARD TABLE, INLAID WITH EBONY AND YELLOW AND GREEN IVORY.—DESIGNED BY PAUL FAURÉ

We are indebted to the "*Work-shop*" for the examples herewith given of inlaid work for card tables. The workmanship was executed at G. Baugrand's establishment, Paris. These designs may prove to be of service for various other kinds of ornamentation. For inlaid work they are certainly admirable.

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